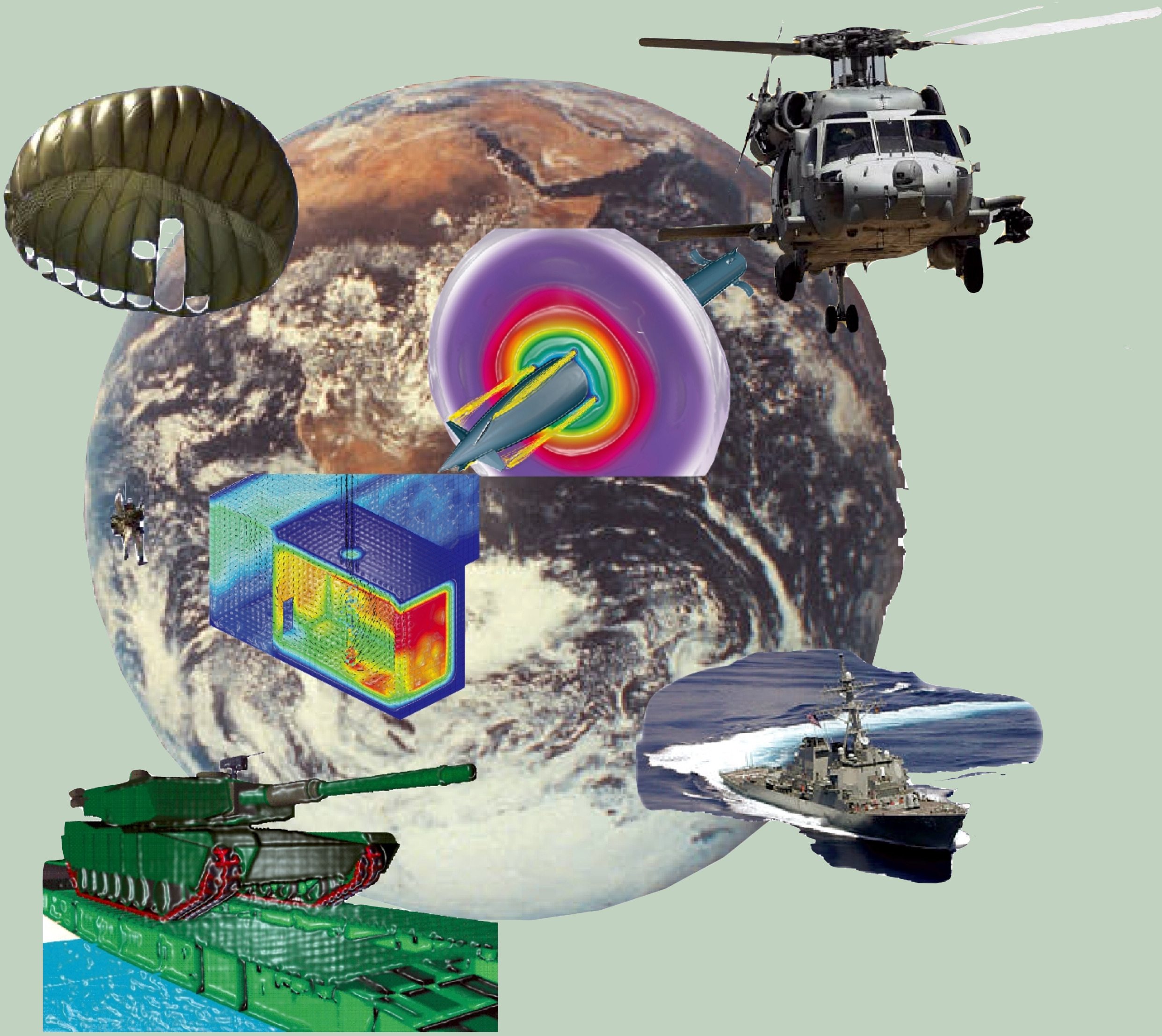
DoD HPC
MODERNIZATION PROGRAM

Modernization Plan 2002



High Performance Computing Tools for the 21st Century

Front cover captions (clockwise starting from top left):

An Air Force Pararescueman with the 38th Rescue Squadron, Moody Air Force Base, Georgia, makes a static jump from an HC-130 over the B-16 range at Fallon Naval Air Station, Nev., June 19, 2001 (U.S. Air Force photo)

Guided MLRS pressure contours and particle traces (DoD Mission Success Stories 2000 pg. 98)

An HH-60 helicopter heads back to home station after successfully hitting a simulated target at range B-17 during a hellfire demonstration for the exercise June 22, 2001 (U.S. Air Force photo)

The U.S. Navy Arleigh Burke class guided missile destroyer USS Cole (DDG 67) taken September 14, 2000, approximately one month before being attacked by a terrorist-suicide mission during the early morning hours of October 12th, 2000 (U.S. Navy photo)

DoD Mission Success Stories 2000 pg. 117

This figure shows the results of a calculation of an incendiary payload burning in a structure containing a BW agent simulant. (The walls of the structure facing the viewer are not shown.) The colored circles represent solid products from the combustion of the incendiary, where the color indicates the temperature of each particle. The colored contours plotted on solid surfaces show the air temperature adjacent to the surface. The black arrows indicate velocity plotted on a plane intersecting the computational domain. (DoD Mission Success Stories 2000 pg. 109)

For more information about the DoD HPC Modernization Office and the DoD HPC Modernization Program, visit our Web site at http://www.hpcmo.hpc.mil

HPC DoD Modernization Program

Department of Defense

High Performance Computing Modernization Program

Modernization Plan 2002

February 2002

OFFICE OF THE DIRECTOR OF
DEFENSE RESEARCH AND ENGINEERING
3040 DEFENSE PENTAGON
WASHINGTON, D.C. 20301-3040

MAR 13 2002

This is the seventh edition of the Department of Defense High Performance Computing Modernization Plan. We continue to make significant progress in improving the department's ability to exploit leading-edge computational technology to provide the warfighter with the technological advantage. With several new acquisitions this fiscal year, the program will continue to provide the department's scientists and engineers with the most current computing power and networking services available. The modernization and expansion of the Department of Defense's high performance computing capability dramatically impacts the research, development, and acquisition of DoD warfighting systems.

High performance computing, a critical enabling technology, has changed the Department of Defense. Its use in detailed, high fidelity computational modeling and simulation has resulted in improved research, expanded test envelopes, improved acquisition decisions, and improved analyses. The program provides a pervasive culture where scientists and engineers routinely use advanced computational environments to develop joint need HPC applications, software tools, and programming environments to assure our armed forces retain a technological advantage and force dominance on tomorrow's battlefield. This plan includes examples of the types of research, tests, and simulations made possible by high performance computing within the Defense Department. A more comprehensive presentation of project successes using high performance computing can be found in the technical report *High Performance Computing Contributions to DoD Mission Success*. In addition, more Program achievements have been highlighted in the Institute of Electrical & Electronics Engineers Computer Society and the American Institute of Physics March/April 2002 issue of *Computing in Science and Engineering*.

Sincerely,

Charles J. Holland

Charles J. Holland
Deputy Under Secretary of Defense
(Science and Technology)

Executive Summary

Under the auspices of the Deputy Under Secretary of Defense (Science and Technology), the High Performance Computing Modernization Program continues to focus on acquiring, managing, and sustaining modern commercial high performance computing (HPC) resources. High performance computing resources allow the United States to develop and deploy superior weapons, warfighting capabilities, and mission support systems.

The *2002 High Performance Computing Modernization Plan* includes a program overview, several recent examples of defense projects successfully employing high performance computing resources, and a section on program accomplishments and future plans, with an emphasis on fiscal years 2002 and 2003.

The program's overarching goal continues to be the exploitation of high performance computing technology for military advantage. The strategy remains to acquire and sustain world-class high performance computing and network capabilities to support defense scientists and engineers. The program supports over 600 high performance computing projects, and over 4,300 scientists and engineers located at more than 100 Department of Defense (DoD) laboratories, universities, test centers, and industrial sites.

The program puts advanced technology in the hands of U.S. forces quicker, cheaper, and with greater certainty of success. Today's weapons programs, such as the Joint Strike Fighter, Unmanned Aerial Vehicles, the Bradley Tank, and the Avenger Missile Program have benefited from HPC. Benefits include innovative materials, advanced design concepts, improved designs, more accurate simulations, and more efficient tests. High performance computing is a key factor in many major DoD acquisition programs. The use of high performance computing technology reduces the costs and time required for systems analysis, design, development, test, and deployment; helps avoid environmental damage; and improves the integration and effectiveness of complex weapons systems. As DoD continues to reform and reengineer its acquisition processes, high performance computing assets, along with high-fidelity scalable models and simulations, reduce the number of expensive prototypes. Modeling and simulation are being used to explore detailed design options and to identify testing priorities earlier in the design cycle.

Future weapons systems, such as high power microwave weapons, are benefiting through basic research. Plasma physics, molecular engineering, high-energy materials, and advanced signal processing are some of the challenges currently addressed by the program.

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Picture Captions (from right to Left):

A B-1B Lancer from the 28th Air Expeditionary Wing heads for Afghanistan after receiving fuel from a KC-10 Extender from the 60th Air Expeditionary Group in the late evening, Nov. 27, 2001, Operation Enduring Freedom. (U.S. Air Force photo by Tech. Sgt. Cedric H. Rudisill) (Released). Photo by TECH. SGT. CEDRIC H RUDISILL, 1ST COMBAT CAMERA SQ.

KANDAHAR (December 28, 2001) — At the U.S. Marine Corps Base in Kandahar, Afghanistan, Marines on a Light Armored Vehicle (LAV) prepare to go on patrol as an AH1W Super Cobra helicopter flys overhead. U.S. Marines are in Afghanistan operating in support of Operation Enduring Freedom. U.S. Navy photo by Chief Photographer's Mate Johnny Bivera, Fleet Combat Camera Atlantic (RELEASED). Photo by PHC JOHNNY BIVERA, FLEET COMBAT CAMERA ATLANTIC.

133rd Airlift Wing, Minnesota Air National Guard, Minneapolis-St. Paul. Flag at half mast in front of the headquarters building on Sept. 20, 2001. (U.S. Air Force photo by Tech. Sgt. Devona Maher) (Released). Photo b: TSGT DEVONA MAHER, 133 COMMUNICATIONS FLIGHT.

Program Mission

The HPCMP mission is to deliver world-class commercial, high-end, high performance computational capability to the DoD's science and technology and test and evaluation communities facilitating the rapid application of advanced technology into superior warfighting capabilities.

Program Vision

The HPCMP vision is to provide a pervasive culture among DoD's scientists and engineers where they routinely use advanced computational environments to solve the most demanding problems.

Program Overview

Introduction

The High Performance Computing Modernization Program (HPCMP) was initiated in 1993 in response to congressional direction to modernize the Department of Defense (DoD) laboratories' high performance computing (HPC) capabilities. Early on, senior leaders recognized this technology as critical to our nation's future defense. Today, the HPCMP fields world-class, commercial high performance computing resources to support the full science and technology (S&T) and test and evaluation (T&E) communities. These resources include a balanced set of major shared resource centers, smaller focused distributed centers, wide area networking services, and HPC software applications support. Figure 1 shows the HPC center locations and Figure 2 depicts the integrated program strategy.

Program Scope

The HPCMP scope is bounded both in terms of the user community it serves and the technological capability that it delivers. By concentrating the majority of resources at a small number of HPC centers, the program has been able to provide computing capabilities that could not have efficiently been obtained and sustained by individual Services or

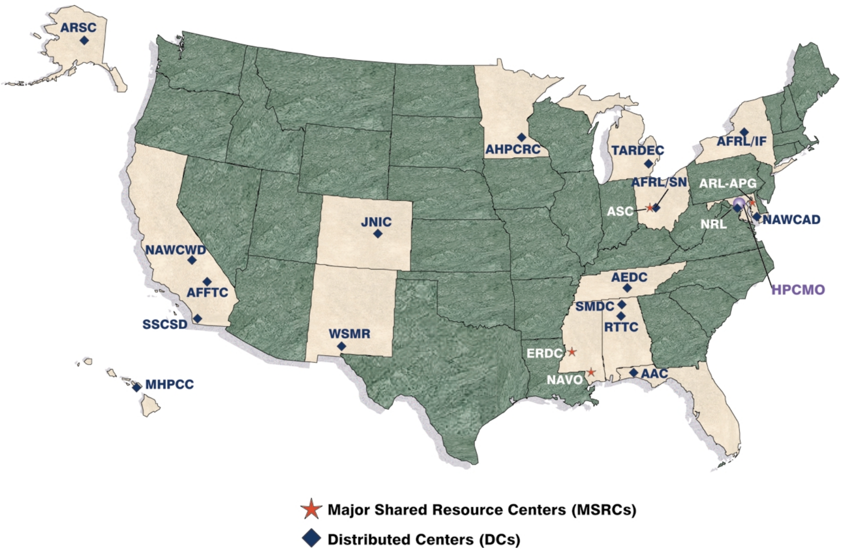


Figure 1. High Performance Computing Shared Resource Centers

Agencies. This sharing of resources reduces overall acquisition and sustainment costs and fosters collaboration and cooperation across the DoD S&T and T&E communities. The scope of the user community is defined by the Congress (Public Law 104-61, December 1, 1995, 109 Statute 665, Sec. 8073) to be

> *"(1) the DoD Science and Technology sites under the cognizance of the DDR&E, (2) the DoD Test and Evaluation centers under the Director, Test and Evaluation OUSD (A&T), and (3) the Ballistic Missile Defense Organization."*

The program maintains a strict focus on providing high performance computing. The definition of "high performance computing" changes as the technology continues to evolve. This evolution requires that the program periodically reassess its acquisition plans to ensure that it is not acquiring "departmental" class systems, which remain the responsibility of the local organization. The rapid evolution of high performance computing requires that the program focus on delivering improved capability early in a weapon systems life cycle. This allows the DoD to maintain the technological edge required to analyze, design, produce, and deploy advanced weapons systems and capabilities to the warfighter—before similar computational capabilities are available to our adversaries.

User Requirements and Resource Allocations

From its beginning, the HPCMP was designed to address the continuing high-end computing needs of the DoD S&T program. Congress later expanded the program's scope to include the T&E community. The program currently has a user base of over 4,300 scientists and engineers located at more than 100 DoD laboratories, test centers, universities, and industrial sites. In order to focus on the needs of those scientists and engineers, the program office has developed a multi-level methodology for determining user requirements and for establishing resource allocations that reflect Departmental priorities.

The requirements process, developed and employed by the program, includes an annual survey of the DoD S&T and T&E communities, coupled with site visits to discuss requirements and provide information to user groups. Working with representatives of the user community, the program office identifies and tracks requirements at the computational project level. The program also obtains feedback through user satisfaction surveys, annual user group meetings, and functional and technical advisory panels.

The High Performance Computing Modernization Program Office (HPCMO) tracks HPC systems performance metrics throughout the year at the computational project level to ensure projects receiving allocations are able to use the resources effectively and efficiently. This process provides feedback to the Services and Agencies allowing resources to be reallocated to the projects best positioned to make progress. The overall integrated process furnishes accurate and timely data on which to base program decisions.

The DoD computational community has become more sophisticated in its use of HPC resources. Consequently, the program needed a representative, reflective, and forward-looking set of benchmarks. In 2000, the HPCMO formed a software analysis and benchmark team to oversee development of a new set of benchmarks. The program's new benchmark suite is more representative of the application codes run by DoD's S&T and T&E communities on HPCMP systems. Every year, the benchmark suite is reviewed and updated. It is used as an important criterion in the acquisition of HPC systems. The new benchmarks were augmented in fiscal year 2001 and implemented in the last system acquisition process.

Twenty to twenty-five percent of the program's total resources are dedicated each year to a set of DoD HPC Challenge Projects. These computationally intensive, high-priority projects are selected annually through a rigorous technical and mission relevance

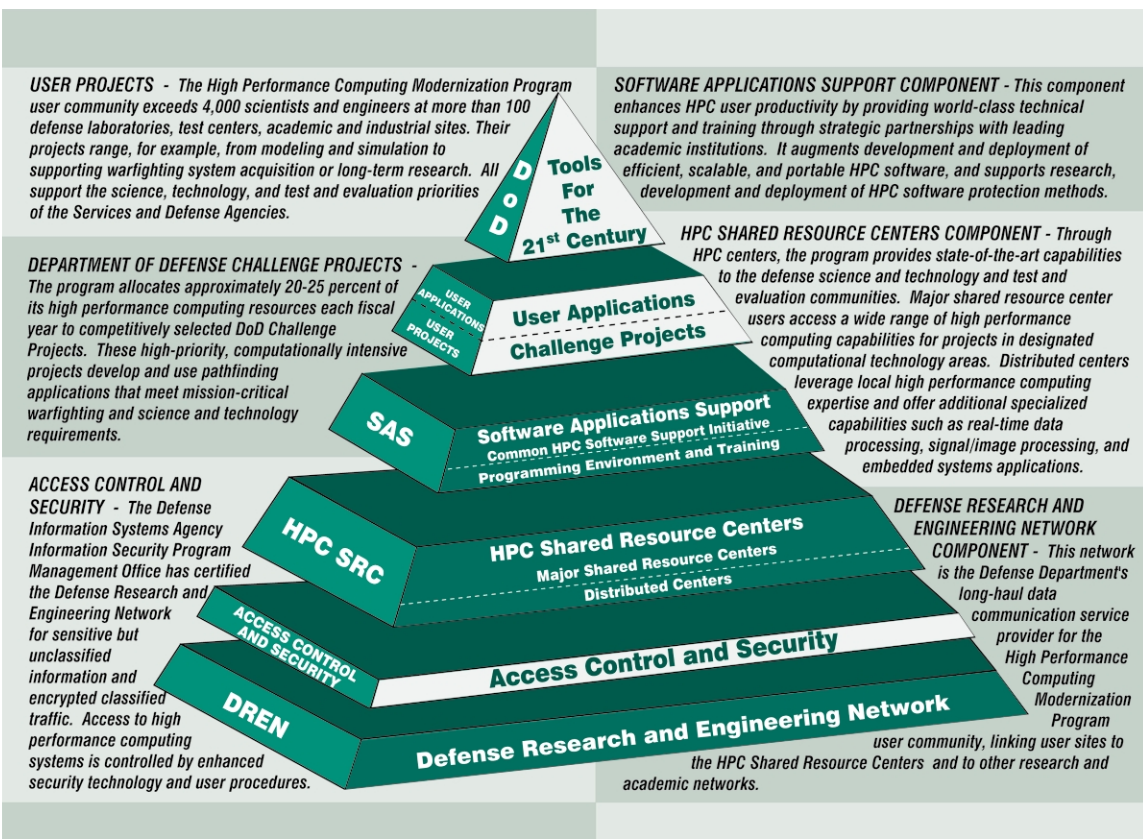


Figure 2. Integrated Program Strategy of the Department of Defense High Performance Computing Modernization Program

evaluation. Services and Agencies allocate the remaining resources through Service and Agency unique processes.

Challenge Project efforts produce and support key enabling technologies, capabilities, and demonstrations expressed by the Defense Technology Objectives (DTOs). These enabling DTOs, in turn, support Joint Vision 2020 and the thirteen Joint Warfighting Capability Objectives (JWCOs) promulgated by the Joint Requirements Oversight Council of the Joint Chiefs of Staff. While not all-inclusive, JWCOs provide focus, priority, and a common reference point for much of the DoD's research, test, and evaluation efforts. They are described in detail in the annual Joint Warfighting Science and Technology Plan (JWSTP). Table 1 provides a few examples of HPC projects and their value to the warfighting community.

Computational Technology Areas

The DoD HPCMP user community is organized around ten broad computational technology areas (CTAs). Each CTA has a designated leader, a prominent DoD scientist or engineer, working in the discipline. Table 2 provides a brief description of each CTA and Table 3 lists the current CTA leaders.

Table 1. Examples of High Performance Computing Projects and Their Value to the Warfighter

Project	Value to the Warfighter and Joint Warfighting Capability Objectives Supported
Operational Wave Forecasting in Scalable Environments	Enables development of a state-of-the-art wave modeling technology which can provide timely forecasts to military operations. (Joint Readiness and Logistics and Sustainment of Strategic Systems)
Real-Time Processing of Hyperspectral Sensor Data	Enables scientists to evaluate the next generation of passive standoff chemical warfare agent detectors. These detectors will assess and disseminate threat information more quickly by providing the needed data analysis in real-time. (Chemical/Biological Warfare Defense and Protection and Counter Weapons of Mass Destruction)
CFD-Based Rotorcraft Improvement Studies	Enables the prediction of loads, performance, and acoustics of rotor aircraft in various modes of operation; allows the improvement of rotor aircraft designs; and answers the question of whether to field new aircraft or modernize the existing fleet. (Force Projection/Dominant Maneuver)
Ordnance Detonation and Penetration Mechanics Modeling	Enables the modeling of high-impact explosive warheads, reducing the number of live tests required, at a significant savings over live ordnance testing. (Precision Fires, Joint Readiness and Logistics and Sustainment of Strategic Systems)
Weapons of Mass Destruction (WMD) Defeat Payload Development	Enables the development of payloads for air-dropped munitions which destroy or deny the use of WMD while minimizing the associated collateral effects. (Precision Fires, Chemical/Biological Warfare Defense and Protection and Counter Weapons of Mass Destruction)
Contaminant Transport Modeling in Complex Urban Environments	Enables the development of a contaminant transport model to study the effects of chemical/biological agents released into the atmosphere; results can support consequence management operations. (Military Operations on Urbanized Terrain, Joint Readiness and Logistics and Sustainment of Strategic Systems, Chemical/Biological Warfare Defense and Protection and Counter Weapons of Mass Destruction)

Table 2. Computational Technology Areas

	CTA	Description
CSM	**Computational Structural Mechanics**	Covers the high resolution, multi-dimensional modeling of materials and structures subjected to a broad range of loading conditions including static, dynamic, and impulsive. CSM encompasses a wide range of engineering problems in solid mechanics such as linear elastic stress analysis. CSM is used for basic studies in continuum mechanics, stress analysis for engineering design studies, and structural and material response predictions to impulsive loads.
CFD	**Computational Fluid Dynamics**	Covers high performance computations whose goal is the accurate numerical solution of the equations describing fluid and gas motion. CFD is used for basic studies of fluid dynamics for engineering design of complex flow configurations and for predicting the interactions of chemistry with fluid flow for combustion and propulsion.
CCM	**Computational Chemistry and Materials Science**	Covers the computational research tools used to predict basic properties of new chemical species and materials which may be difficult or impossible to obtain experimentally. Within DoD, quantum chemistry and molecular dynamics methods are used to design new chemical systems and solid state modeling techniques are employed in the development of new high-performance materials.
CEA	**Computational Electromagnetics and Acoustics**	Covers the high-resolution, multi-dimensional solutions of Maxwell's equations as well as the high-resolution, multi-dimensional solutions of the acoustic wave equations in solids, fluids, and gases. Some DoD applications include calculating the electromagnetic fields about antenna arrays, the electromagnetic signatures of tactical ground, air, sea and space vehicles, the electromagnetic signature of buried munitions, high power microwave performance, as well as the interdisciplinary applications in magnetohydrodynamics and laser systems.
CWO	**Climate/Weather/Ocean Modeling and Simulation**	Is concerned with the accurate numerical simulation of the earth's climate including the simulation and forecast of atmospheric variability and oceanic variability. CWO includes the development of numerical algorithms and techniques for the assimilation of in-situ and remotely sensed observations into numerical prediction systems.
SIP	**Signal/Image Processing**	Emphasizes research, evaluation, and test of the latest signal processing concepts directed toward these embedded systems. This will enable the traditional expensive, military-unique 'black boxes' required to implement high-speed signal/image processing to be replaced by commercial-off-the-shelf (COTS) HPC-based equipment.
FMS/ C4I	**Forces Modeling and Simulation**	Focuses on force level modeling and simulation for training, analysis, and acquisition. The acquisition domain includes research and development, test and evaluation, and production and logistics. The overarching Simulation Based Acquisition domain is included.
EQM	**Environmental Quality Modeling and Simulation**	Covers the high-resolution, three-dimensional Navier-Stokes modeling of hydrodynamics and contaminant and multi-constituent fate/transport through the aquatic and terrestrial ecosystem and wetland subsystems, their coupled hydrogeologic pathways, and their interconnections with numerous biological species.
CEN	**Computational Electronics and Nanoelectronics**	Uses advanced computational methods to model and simulate complex electronics for communications, command, control, electronic warfare, signal intelligence, sensing, and related applications. Use of high performance computing assets enables the DoD electronics community to solve complex problems, explore new concepts, gain insight and improved understanding of the underlying physics, perform virtual prototyping, and test new ideas.
IMT	**Integrated Modeling and Test Environments**	Addresses the application of integrated models, simulation tools and techniques with live tests and hardware-in-the-loop simulations. IMT also provides proof-of-concept by using technology-based war gaming modeling and software integration tools for the simulation of weapon component subsystems and systems in a virtual operational context.

Table 3. Computational Technology Area Leaders

Computational Technology Area	Leader
Computational Structural Mechanics	Mr. Michael Giltrud Defense Threat Reduction Agency, Alexandria, VA
Computational Fluid Dynamics	Dr. Robert Meakin Army Aviation and Missile Command, Moffett Field, CA
Computational Chemistry and Materials Science	Dr. Ruth Pachter Air Force Research Laboratory, Materials/Manufacturing Directorate, Wright-Patterson Air Force Base (AFB), OH
Computational Electromagnetics and Acoustics	Dr. Robert Peterkin Air Force Research Laboratory, Directed Energy Directorate, Kirtland AFB, NM
Climate, Weather, and Ocean Modeling and Simulation	Dr. William Burnett Naval Oceanographic Office, John C. Stennis Space Center, MS
Signal/Image Processing	Dr. Anders Sullivan Army Research Laboratory, Aberdeen Proving Ground, MD
Forces Modeling and Simulation/C4I	Dr. Larry Peterson Space and Naval Warfare Systems Center, San Diego, CA
Environmental Quality Modeling and Simulation	Dr. Jeffrey Holland Engineer Research and Development Center, Vicksburg, MS
Computational Electronics and Nanoelectronics	Dr. Barry Perlman Army Communications-Electronics Command Research Development and Engineering Center, Ft. Monmouth, NJ
Integrated Modeling and Test Environments	Mr. Jere Matty Arnold Engineering Development Center, Arnold Air Force Base (AFB), TN

Program Goals

The Program has five overarching goals to achieve the program's vision:

(1) Provide the best commercially available high-end HPC capability.

(2) Acquire and develop joint need HPC applications, software tools, and programming environments.

(3) Educate and train DoD's scientists and engineers to effectively use advanced computational environments.

(4) Link users and computer sites via high-capacity networks, facilitating user access and distributed computing environments.

(5) Promote collaborative relationships among the DoD HPC community, the national HPC community and Minority Serving Institutions (MSIs) in network, computer, and computational science.

Program Strategies

The program implements the following strategies to achieve the five program goals:

Goal	Strategies
Provide the best commercially available high-end HPC capability.	• Provide a balanced set of commercially available heterogeneous computing platforms and HPC systems to meet the full range of DoD requirements. • Permit the optimum mapping of requirements to system types. • Conduct an annual benchmarking process that relates HPC systems performance to the program's computational requirements. • Build complete HPC environments, including large computing systems, software, and support expertise at a few DoD laboratories designated as major shared resource centers (MSRCs) to support a wide community of users. • Place modest-sized HPC systems at selected distributed centers (DCs) when that allows for either innovation or mission support not provided by a major shared resource center. • Support efforts to build complementary HPC capabilities and technologies throughout government, academia, and industry that are applicable to defense S&T and T&E requirements. • Continually acquire and upgrade equipment and support services to ensure that DoD HPC centers provide world-class, commercial, state-of-the-art capabilities.
Acquire and develop joint need HPC applications, software tools, and programming environments.	• Encourage use of standards for defense research, development, test, and evaluation software to ensure future transitions and advancements in software technology are applied in an efficient, cost-effective manner. • Focus on applications software projects designed to overcome technological inhibitors that may delay the effective use of scalable high performance computers. • Support software components used in specific computational technology areas or by a subset of HPC users across the community. • Identify software suites to be shared across major shared resource centers and selected distributed centers.
Educate and train DoD's scientists and engineers to effectively use advanced computational environments.	• Provide user education in scalable computer and computational sciences, software applications and optimization, and code conversion. • Promote the formation of DoD-sponsored interdisciplinary teams and collaborative groups to determine how best to support each computational technology area and to leverage academia and industry expertise in HPC for the solution of DoD problems. • Develop shared application software in support of high-priority and broadly based computational technology area needs. • Aggressively transfer expertise and knowledge among the DoD HPC user communities. • Broaden the knowledge base of the DoD HPC user community based on new applications and their capabilities.
Link users and computer sites via high-capacity networks, facilitating user access and distributed computing environments.	• Deploy a secure, robust, wide area network (WAN) specifically designed to meet the needs of advanced high performance computing in exploiting high fidelity computer models and simulations. • Provide Gigabit range networking services using emerging technologies such as multi-protocol label switches, packet over SONET, packet over lightwave, and lightwave services. • Provide a low latency, high bandwidth WAN suitable for the establishment of truly distributed computational grids, next generation mass storage of data, and the ability to do remote disaster recovery. • Offer DoD scientists and engineers the ability to securely and dynamically allocate bandwidth among different applications and transmission protocols with minimal setup.
Promote collaborative relationships among the DoD HPC community, the national HPC community and MSIs in network, computer, and computational science.	• Ensure that users in the Department's S&T and T&E communities remain cognizant of, interact with, and leverage internal Defense Department initiatives. • Ensure that Defense S&T and T&E users remain cognizant of, collaborate with, and leverage other government, academia, industry, and each other's HPC efforts. • Maintain cooperative contact with the appropriate committees, subcommittees, working groups, and advisory panels associated with the national high performance computing efforts. • Provide HPC resources to support defense applications that directly relate to dual-use technologies and National Challenges, such as environment, medical, digital libraries, and manufacturing processes and products. • Ensure the widest possible success of DoD HPC Challenge Projects. Leverage the nation's HPC infrastructure to benefit the warfighter.

Program Components

The program is organized into three components to achieve its goals. The components are HPC shared resource centers, networking, and software applications support. The components allow the program to focus on the most efficient means of supporting the S&T and T&E communities' requirements. The components align to the program goals as follows:

	HPC Shared Resource Centers	Networking	Software Applications Support
Goal 1 - HPC Capability	X		X
Goal 2 - HPC Applications, Software Tools, and Support	X		X
Goal 3 - Education and Training	X	X	X
Goal 4 - Networking Environment		X	
Goal 5 - Collaborative Relationships	X	X	X

High Performance Computing Shared Resource Centers

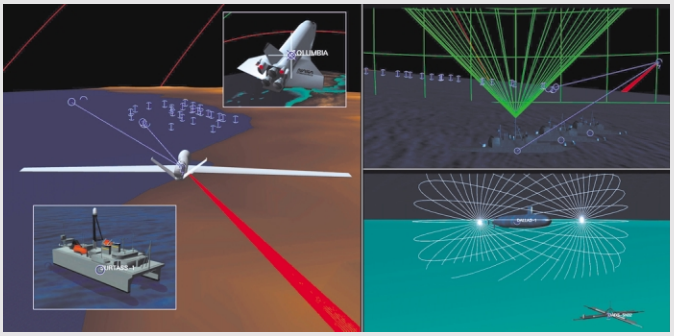
Major Shared Resource Centers

The HPCMP operates four large major shared resource centers (MSRCs) that enable the DoD S&T and T&E communities to effectively use the full range of HPC resources. Each MSRC is operated and maintained by a team of government and contractor personnel. The four MSRCs are:

- Aeronautical Systems Center (ASC), Wright-Patterson AFB, OH
- Army Research Laboratory (ARL), Aberdeen Proving Ground, MD
- Army Engineer Research and Development Center (ERDC), Vicksburg, MS
- Naval Oceanographic Office (NAVO), John C. Stennis Space Center, MS

Each MSRC includes a robust complement of high-end, high performance computing and communications systems. System capabilities include scientific visualization, peripheral and archival mass storage devices, and support staff. MSRCs support a wide range of computational projects.

In the past, a key element of support provided to users by the MSRCs has been the Programming Environment and Training (PET) effort. This effort has transitioned from separate contracts at the four MSRCs to an integrated, program-wide set



System Virtual Prototyping, a screen capture from the ADVISR real-time, three-dimensional visualization system

***Impact to DoD:** High performance computers and high-bandwidth, low-latency, networking technologies provide a capability to virtual prototype real-time systems and metasystems impacting military sensors, communication, and C2 systems. The technology supports simulating air traffic control communication, drug-enforcement surveillance, and port monitoring.*

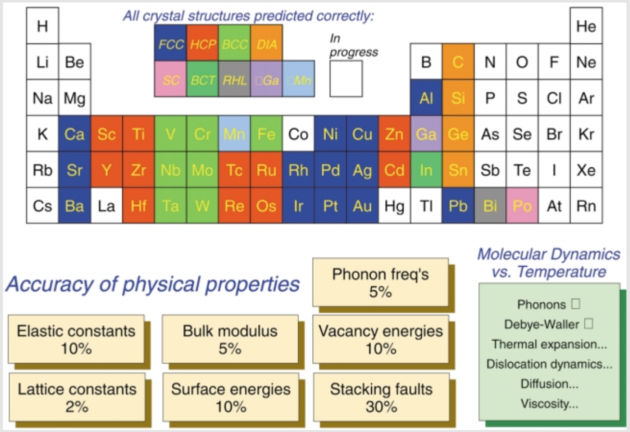
of competitively awarded contracts. Extensive training to meet a wide variety of users needs and incorporating state-of-the-art system tools and HPC technology facilitate the efficient use of the various HPC systems. This support is a collaborative partnership established by the HPCMP with leading civilian HPC centers and academic institutions. Such rapid collaboration fosters innovation and draws additional HPC technology and expertise into the DoD. MSRCs also focus on training the DoD user base, identifying HPC technology opportunities, and introducing these opportunities into all HPC centers' computing environments.

Distributed Centers

Distributed centers (DCs) provide HPC capability to local and remote portions of the program's user community. Modest-sized systems are deployed to DCs where there is a significant advantage of using a local HPC system and the potential for advancing DoD applications. DCs leverage HPC expertise or address problems that cannot be readily solved at the MSRCs. The DCs are linked by high-speed communications to the MSRCs and remote users. Thus, they augment the MSRCs, forming the total DoD HPCMP computational capability.

Some DCs primarily focus on real-time data processing/simulation, signal image processing, and embedded systems applications. These centers provide dedicated computational resources targeted to support local mission requirements. These centers include:

- Air Armament Center (AAC), Eglin AFB, FL
- Air Force Flight Test Center (AFFTC), Edwards AFB, CA
- Air Force Research Laboratory, Information Directorate (AFRL/IF), Rome, NY
- Air Force Research Laboratory, Sensors Directorate (AFRL/SN), Wright-Patterson AFB, OH
- Arnold Engineering Development Center (AEDC), Arnold AFB, TN
- Joint National Integration Center (JNIC), Schriever AFB, CO
- Naval Air Warfare Center Aircraft Division (NAWCAD), Patuxent River, MD
- Naval Air Warfare Center Weapons Division (NAWCWD), China Lake, CA
- Redstone Technical Test Center (RTTC), Huntsville, AL



The colored squares indicate those elements for which we have developed tight-binding parameters, and show the ground-state crystal structure of each element. The figure also indicates the accuracy of physical properties determined by the method. These accuracies are comparable to first-principles results. Finally, molecular dynamics capabilities are shown in the green box.

Impact to DoD: *DoD researchers are using high performance computers to develop an efficient computational method for studying materials properties which will lead to the design of new materials for DoD needs.*

- Space and Naval Warfare Systems Center (SSCSD), San Diego, CA
- Tank Automotive Research, Development and Engineering Center (TARDEC), Warren, MI
- White Sands Missile Range (WSMR), White Sands Missile Range, NM

Other centers focus on non-real-time computing, short turnaround requirements, Challenge Projects, and early access technology transfer. These centers provide significant resources to supplement MSRCs and are configured to support multiple tasks and process multiple requests. The DCs are:

- Arctic Region Supercomputing Center (ARSC), Fairbanks, AK
- Army High Performance Computing Research Center (AHPCRC), Minneapolis, MN
- Maui High Performance Computing Center (MHPCC), Kihei, HI
- Naval Research Laboratory (NRL-DC), Washington, DC
- Space and Missile Defense Command (SMDC), Huntsville, AL

Networking

Defense Research and Engineering Network

The Defense Research and Engineering Network (DREN) is DoD's recognized research and engineering network. Figure 3 graphically displays the DREN connections for the program's HPC centers and other wide area network (WAN) access points. The DREN is a robust, high-speed network that provides connectivity between the HPCMP's geographically dispersed user sites and shared resource centers. Since users and resources are scattered throughout the United States, strong interconnectivity with other major networks and high performance test beds at key exchange points are critical for optimal use of DoD high performance computers.

The networking services of DREN are provided as a contract service. The service provider has built the DREN as a virtual private network

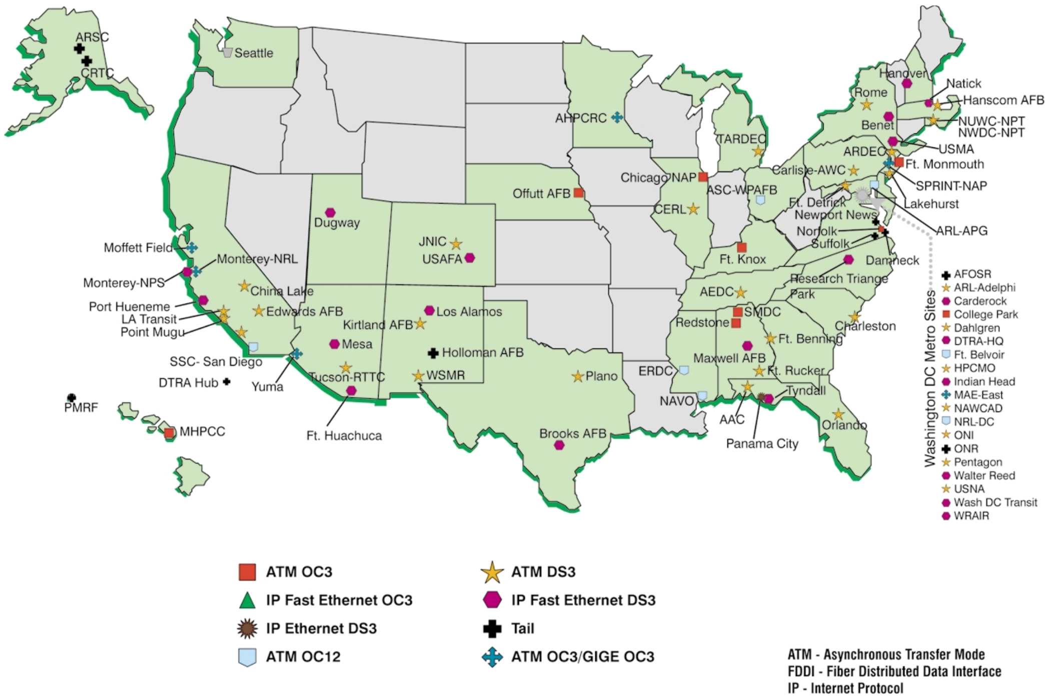


Figure 3. DREN Connections, High Performance Computing Shared Resource Centers, and Other Network Access Points

(VPN) over a public infrastructure. The DREN provides for digital data transfer services between defined service delivery points (SDPs). SDPs are specified in terms of WAN bandwidth access, network protocols [Multi PROTOCAL LABEL switching, Internet Protocol, Asynchronous Transfer Mode], and local connection interfaces. DREN supports bandwidths from DS-3 at user sites to OC-12 at selected DC and MSRCs. Future bandwidths will scale to OC-192 and beyond. DREN services may be at any point in the continental United States, Alaska, or Hawaii, or other overseas sites. Incorporating the best operational capabilities of both the DoD and the commercial telecommunications infrastructure, the DREN is the official DoD long-haul network for computational research and testing in support of DoD's S&T and T&E communities.

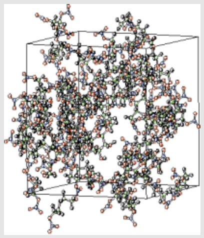
Since its inception, DREN has been active in transferring leading edge network and security technologies across DoD and other federal agencies.

Security

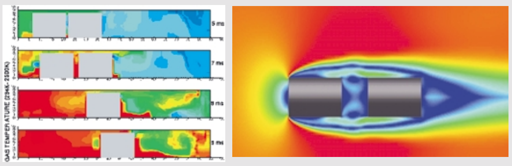
The program's security-in-depth model is one of the most effective security programs in use today. The security-in-depth model uses layers of defense, ranging from network protections such as access control lists and intrusion detection to individual systems with very strong authentication and identification, strong configuration management, periodic physical and logical examination, and active monitoring. The program office implements security at the HPC site level to protect HPC resources and users and at the network level for the HPC community.

The security posture of each HPC site is verified before it is authorized to connect to the DREN. While the HPCMP retains overall security policy and oversight responsibilities, security certification and accreditation are done at the individual site level with accreditation delegated to the host Services. The host Services certify user sites while the HPCMP is responsible for certifying HPC centers. A security test

MolecularModeling



Performance Modeling



Advanced Weapons Systems for Army After Next

Impact to DoD: *High performance computing enables the development and design of advanced energetic materials through predicting/tailoring properties and performance by reducing the need for large scale test and evaluation and reducing the development and life costs through smart design.*

and evaluation team, led by organizations such as the Space and Naval Warfare Systems Center, San Diego, performs HPC center certification. The HPCMP also performs site assistance visits annually and periodically sponsors independent National Security Agency (NSA) security assessments.

HPC centers and user sites with classified computing requirements are accredited and certified at the appropriate classification level. The HPCMP requires that copies of memoranda of agreement, in accordance with Department of Defense Directive 5200.28, be on file before allowing classified communications between user and provider sites. All classified communications use Type 1 NSA approved encryption devices.

For unclassified processing, the HPCMP requires strong identification authentication to ensure access only to authorized users. Authentication uses a combination of Kerberos software, one-time pass codes (currently SecurID cards), and encrypted shell access like KTelnet or SSH Secure Shell software. This provides increased protection from:

- disruption of service to authorized users;
- unauthorized disclosure, copying (theft), or alteration of users' data;
- unauthorized access to HPC centers' computers; and
- misuse of HPC centers' computers.

The HPCMP works closely with other DoD organizations to ensure that the DREN and all connected sites meet Service and Office of the Secretary of Defense security regulations and requirements. At the network level, the HPC Computer Emergency Response Team (CERT) monitors the DREN using network intrusion detection systems running Department of Energy developed Joint Intrusion Detection and other software. Access control lists on external network devices further protect DREN users from known sources of attack.

Software Applications Support

"Software Applications Support" is new terminology that captures the evolutionary nature of the Program's efforts to accomplish goals 2, "Acquire and develop joint need HPC applications, software tools, and programming environments", and 3, "Educate and train DoD's scientists and engineers to effectively use advanced computational environments". As the program has evolved, the potential synergy of re-focusing programming environment and training (PET) activities caused the HPCMP to realign PET from a shared resource center centric orientation to a broader program-wide focus.

This realignment offers significant opportunities for leveraging and collaboration with CHSSI. In 2001, PET transitioned from separate contracts at the four MSRCs to an integrated, program-wide set of competitively awarded contracts.

Common High Performance Computing Software Support Initiative

The Common High Performance Computing Software Support Initiative (CHSSI) provides DoD scientists and engineers efficient, scalable, portable software codes, algorithms, tools, models, and simulations that run on a variety of HPC platforms. CHSSI, which is organized around ten computational technology areas, involves several hundred scientists and engineers working in close collaboration across government, industry, and academia. CHSSI teams include algorithm developers, applications specialists, computational scientists, computer scientists, engineers, and end users. Software developed by CHSSI is CTA-specific or multi-disciplinary. Portfolios combining multi-disciplinary projects focus on readily understood warfighter needs.

Developing software for scalable HPC systems is technically challenging and labor intensive. CHSSI helps the DoD take advantage of existing and future computing and communications capabilities by building software with an emphasis on reusability, scalability, portability, and maintainability. In addition, CHSSI is producing a new generation of world-class scientists and engineers trained in scalable software techniques that will reduce the future costs of doing business and increase our future defense capabilities. Table 4 lists the current 35 CHSSI projects with principal investigators.

Programming Environment and Training

The Programming Environment and Training (PET) component enables the DoD HPC user community to make the best use of the computing capacity the HPCMP provides and to extend the range of DoD technical problems solved on HPC systems. PET enhances the total capability and productivity of users through training, collaboration, tool development, software development support, technology tracking, technology transfer, and outreach.

PET activities consist of short- and long-term strategic efforts. Short-term efforts include on-site training and short collaborative projects with users. Examples of long-term efforts are distance learning and metacomputing. The PET initiative allows the DoD to shape the direction of HPC through participation and partnership.

Part of the PET approach is to marshal elite and readily accessible university teams by creating an information conduit between DoD HPC users and top academic experts. PET teams are able to both anticipate and respond to the needs of DoD users for training and assistance in advancing the programming environment. The teams have a strong on-site presence and interact daily with HPCMP staffs and users, with additional support by senior level researchers at universities.

Software Protection

Software protection is a focused research and development effort to design and implement specific mechanisms to HPC software applications to protect the intellectual content of these codes from unauthorized use.

Table 4. Common HPC Software Support Initiative Projects and Principal Investigators (Fiscal Year 2002)

Project	Principal Investigator	Organization
Computational Structural Mechanics		
A Next Generation Scalable Finite Element Software to Describe Fracture and Fragmentation of Solids and Structures	A.M. Rajendran	Army Research Laboratory, Aberdeen Proving Ground, MD
Computational Fluid Dynamics		
Parallelizing SOCRATES - The Air Force Research Laboratory Direct Simulation Monte Carlo Flow Field, Chemistry, and Radiation Code	Thomas Smith	Air Force Research Laboratory, Propulsion Directorate, Wright-Patterson AFB, OH
Unstructured Overset Grid Framework for Moving Body Applications	Jere Matty	Arnold Engineering Development Center, Arnold AFB, TN
Computational Chemistry and Materials Science		
Tight Binding Molecular Dynamics	Dimitris Papaconstantopoulos	Naval Research Laboratory, Washington, DC
Molecular Dynamics for Energetic and Non-Energetic Materials	Richard Mowrey	Naval Research Laboratory, Washington, DC
Computational Electromagnetics and Acoustics		
A Scalable, Dynamically Adaptive Mesh Software Package for General Magnetohydrodynamic and Space Weather Modeling	Sprios Antiochos	Naval Research Laboratory, Washington, DC
High-Resolution Modeling of Acoustic Wave Propagation in Atmospheric Environments	D. Keith Wilson	Army Research Laboratory, Aberdeen Proving Ground, MD
MACH3: Portable, Scalable, Parallel-Computing Magnetohydrodynamics Software for Multi-materials in Complex 3-D Geometry	Robert Peterkin	Air Force Research Laboratory, Directed Energy Directorate, Kirtland AFB, NM
Scalable, Adaptive Large-Scale Structural Acoustics	Joseph Bucaro	Naval Research Laboratory, Washington, DC
Scalable Computer Ocean-Acoustic Propagation Engine (SCOPE)	Stanley Chin-Bing	Naval Research Laboratory, John C. Stennis Space Center, MS
Software Development for Electromagnetic Sensing of Surface and Subsurface Targets: Simulation and Signal Processing	Anders Sullivan	Army Research Laboratory, Adelphi, MD

Table 4—*Continued*. Common HPC Software Support Initiative Projects and Principal Investigators (Fiscal Year 2002)

Project	Principal Investigator	Organization
Signal/Image Processing		
Acoustic Analysis Workbench Using Windows NT	Keith Bromley	Space and Naval Warfare Systems Center, San Diego, CA
Image Fusion and Signal/Image Processing	Richard Linderman	Air Force Research Laboratory, Information Directorate, Rome, NY
Infrared Search and Track Processing for Missile Surveillance	Dennis Cottel	Space and Naval Warfare Systems Center, San Diego, CA
Climate, Weather, and Ocean Modeling and Simulation		
Development of Two Complete Numerical Weather Prediction Systems for Heterogeneous Scalable Computing Environments	Thomas Rosmond	Naval Research Laboratory, Monterey, CA
Satellite Radiance Variational Data Assimilation: Code Migration to Scalable Architectures	Frank Ruggiero	Air Force Research Laboratory, Space Vehicles Directorate, Hanscom AFB, MA
Scalable Ocean Models with Data Assimilation	Alan Wallcraft	Naval Research Laboratory, John C. Stennis Space Center, MS
Scalable Weather Research and Forecast (WRF) Model Development	Jerry Wegiel	Air Force Weather Agency, Offutt AFB, NE
Forces Modeling and Simulation/C4I		
Parallelization of the Joint Interim Mission Model (JIMM)	David Mutschler	Naval Air Warfare Center Aircraft Division, Patuxent River, MD
Simulation of Communications Networks Using Commercial-Off-The Shelf (COTS) Software	Albert Legaspi	Space and Naval Warfare Systems Center, San Diego, CA
Environmental Quality Modeling and Simulation		
Simulation of Land Use Evolution and Toxics Transport on Military Installation Readiness, Training, Testing, and Security	James Westervelt	Engineer Research and Development Center, Vicksburg, MS
Computational Electronics and Nanoelectronics		
Efficient Numerical Solutions to Large-Scale Military Tactical Communications Problems via a Scalable Time Domain Method (Sc-MRTD)	Robert Pastore	Army Communications-Electronics Command, Ft. Monmouth, NJ
Integrated Modeling and Test Environments		
Simulation and Software Implementation of Non-Uniformity Correction (NUC) for Multi-Element Infrared Scene Projector (IRSP) Arrays	Kenneth LeSueur	Redstone Technical Test Center, Redstone Arsenal, AL
HPC in Concurrent Engineering, Modeling and Testing	Andrew Mark	Army Research Laboratory, Aberdeen Proving Ground, MD
Model-Based Test Data Validation	Mark Chappell	Arnold Engineering Development Center, Arnold AFB, TN

Table 4—*Continued*. Common HPC Software Support Initiative Projects and Principal Investigators (Fiscal Year 2002)

Project	Principal Investigator	Organization
Portfolio Modeling and Simulation of the Electronic Battlefield Environment (EBE), Dr. Barry Perlman, Leader		
Design of Multifunctional Multi-Mode Reconfigurable Antenna Systems for Sensing and Communications	Gregory Creech	Air Force Research Laboratory, Sensors Directorate, Wright-Patterson AFB, OH
Electromagnetic Environmental Effects Toolkit	Rosemary Wenchel	Naval Information Warfare Center, Washington, DC
EM Design General Framework for 21st Century Integrated Military Platforms	John Rockway	Space and Naval Warfare Systems Center, San Diego, CA
Portfolio Hyperspectral Image Exploitation (HIE), Dr. Richard Linderman, Leader		
High Performance Computing Software Framework for Hyperspectral Imaging	George Ramseyer	Air Force Research Laboratory, Information Directorate, Rome, NY
Adaptive Spectral Reconnaissance Program Algorithms for HPC	Eric Coolbaugh	Space and Naval Warfare Systems Center, San Diego, CA
Automatic Target Detection in Hyperspectral Imagery Using Principal Components Analysis	Gary Stolovy	Army Research Laboratory, Aberdeen Proving Ground, MD
HPC PALM - High Performance Computing Pairwise Adaptive Spectral Matched Filter for Hyperspectral Image Exploitation	Michael Eismann	Air Force Research Laboratory, Sensors Directorate, Wright-Patterson AFB, OH
Scalable Software for the Analysis (Including Automatic Target Recognition (ATR)) and Compression of Hyperspectral Data	Jeffery Bowles	Naval Research Laboratory, Washington, DC
Atmosphereic Correction for Hyperspectral Imaging Exploitation	Gail Anderson	Air Force Research Laboratory, Space Vehicles Directorate, Hanscom AFB, MA
Portfolio High Fidelity Simulation of Littoral Environments (SLE), Dr. George Heburn, Leader		
Multi-Level Parallelization	Alan Wallcraft	Naval Research Laboratory, John C. Stennis Space Center, MS
Model Integration Framework	Matthew Bettencourt	Naval Research Laboratory, John C. Stennis Space Center, MS
Simulation of Surf Zone Waves and Currents	Jane Smith	Engineer Research and Development Center, Vicksburg, MS
Simulation of Coastal and Estuarine Circulation	Cheryl Blain	Naval Research Laboratory, John C. Stennis Space Center, MS
Near-Shore Sediment Transport	Timothy Keen	Naval Research Laboratory, John C. Stennis Space Center, MS
Scalable Modeling of Tidal Riverine Environments	Charlie Berger	Engineer Research and Development Center, Vicksburg, MS
Advanced Surface Water-Groundwater Connectivity with Linkage to Atmospheric Outputs	Stacy Howington	Engineer Research and Development Center, Vicksburg, MS
M&S Environmental Server	Richard Allard	Naval Research Laboratory, John C. Stennis Space Center, MS

Table 4—*Continued*. Common HPC Software Support Initiative Projects and Principal Investigators (Fiscal Year 2002)

Project	Principal Investigator	Organization
Portfolio Interdisciplinary Computational Environment for Weapon Target Interactions (WTI), Dr. Raja Namburu, Leader		
Penetrator-Target Interaction	Raju Namburu	Army Research Laboratory, Aberdeen Proving Ground, MD
Blast-Structure Interaction	Michael Giltrud	Defense Threat Reduction Agency, Alexandria, VA
Optimization of Weapon-Target Systems Design	Ernest Baker	Engineer Research and Development Center, Vicksburg, MS and Army Research Laboratory, Aberdeen Proving Ground, MD
Portfolio Material by Design (MBD), Dr. Margaret Hurley, Leader		
Design of New Materials Using Computational Chemistry and Materials Science	Jerry Boatz	Air Force Research Laboratory, Materials and Manufacturing Directorate, Edwards AFB, CA
Materials Design Software Suite	Noam Bernstein	Naval Research Laboratory, Washington, DC
Scalable Quasi-Continuum Software	Margaret Hurley	Army Research Laboratory, Aberdeen Proving Ground, MD
Portfolio System of Systems Simulation (SOS), Mr. Rick Cozby, Leader		
Distributed Information Enterprise Modeling and Simulation (DIEMS)	Robert Hillman	Air Force Research Laboratory, Information Directorate, Rome, NY
Virtual Communication Links	Robert Pritchard	Naval Air Warfare Center, Aircraft Division, Patuxent River, MD
Virtual Prototyping and Accelerated Test of DoD Composite Material Combat Systems for Long-Term Prediction of Structural Integrity	Andrew Mark	Army Research Laboratory, Aberdeen Proving Ground, MD
Portfolio Sensor/Scene Processing and Generation (SPG), Dr. Kenneth LeSueur, Leader		
Fast Line-of-Sight Imagery for Target and Exhaust-Plume Signatures (FLITES)	Charles Coker	Air Force Research Laboratory, Propulsion Directorate, Edwards AFB, CA
Scene Generation With Plume Signature for Hardware-in-the-Loop Test Applications	Dan Benedict	Arnold Engineering Development Center, Arnold AFB, TN
OpenIR: Validated Infrared Graphics Rendering Libraries for Scalable Parallel Supercomputers	John Andujar	Naval Air Warfare Center, Aircraft Division, Patuxent River, MD
Hyperspectral Polarimetric (HSIPOL) Scalable Target and Background Signature Model	Jason Coker	Air Force Research Laboratory, Munitions Directorate, Eglin AFB, FL
Parallel Scene Generation/Electromagnetic Modeling of Complex Targets in Complex Clutter and Propagation Environments	Gerard Genello	Air Force Research Laboratory, Sensors Directorate, Wright-Patterson AFB, OH

Program Accomplishments and Future Plans

Introduction

Since its inception in 1992, the HPCMP has matured from vector-based computers such as the Cray-2 and Control Data Cyber 960, to the massively parallel Cray T3E and SGI Origin 2000. Laboratories were once connected by local area networks (LANs) and Wide Area Networks (WANs) with commercial point to point links at data rates of 1.544 million bits per second (Mbps) (T 1) or less. At present, these laboratories are connected by the state-of-the-art Defense Research and Engineering Network (DREN) with asynchronous transfer mode (ATM) and Internet protocol (IP) services providing DS3 connectivity to the user sites and most distributed centers. DREN provides OC3 to OC12 connectivity to the four Major Shared Resource Centers (MSRCs) and selected DCs with data transfer rates of up to 1397 Mbps.

Along with this maturity have come valuable lessons learned allowing the program to streamline many of its processes. This year, many of the contracts have expired, such as the PET and DREN contracts, and the new processes in place allow the program to more effectively and efficiently select new contractors. The acquisition process has also been streamlined. A new acquisition process has been established which allows the HPCMP to buy HPC hardware and services at the best value to the government. This section provides details on what the program has accomplished this past year and what it plans to do in the future.

High Performance Computing Shared Resource Centers

Major Shared Resource Centers

The High Performance Computing Modernization Program (HPCMP) continues to modernize the HPC capabilities of the MSRCs. A key focus area for the next several years is an effort to build the centers' wide area computing environment (computational grids) with an emphasis on peripheral and archival mass storage capabilities. The program also provides user training. Interaction with other government agencies, industry, and academic centers is encouraged, so that defense scientists and engineers can take advantage of the latest high performance computing expertise, capabilities, standards, and infrastructure.

Since the first high performance computing systems were fielded by the program in 1993, the total peak computational high performance computing capability at the MSRCs increased from 30 gigaflops to just over 8,892 gigaflops at the end of fiscal year 2001. The program will continue to modernize the centers to sustain the world-class, high performance computing infrastructure. During fiscal year 2002, the gigaflops of peak computing capability added to the MSRCs will again be substantial, measuring in the teraflops. ("Peak teraflops" represent a simple measure of growth. The term, however, does not consider architecture specific features, nor does it provide a measure of actual performance delivered).

Table 5 shows the high performance computing systems' capability installed at the MSRCs as of February 2002.

Major Shared Resource Centers, Fiscal Year 2001

In fiscal year 2001 the program introduced a new acquisition strategy, called Technology Insertion 2001 (TI-01). The previous process described hardware and software upgrades in terms of Performance Levels. Performance Levels I, II, and III were embedded in the original integration contracts at the four MSRCs. This approach took the DoD HPC environment at the MSRCs from a few modest high performance computing systems to a world-class HPC capability in just five years. TI-01 continued that history of success, but rather than using site-specific contracts, TI-01 was based on a program-wide perspective. TI-01 placed more emphasis on overall composition of HPC user requirements, and how to satisfy as much of those requirements as possible within the funds available. Defining the optimal solution required the examination of the computational requirements in several different ways – by classified/unclassified processing environments, by computational technology area, by Challenge/non-Challenge projects, and by the types of systems needed.

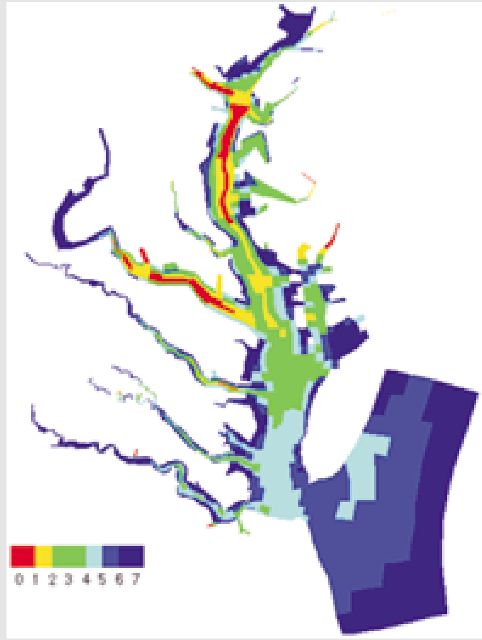
The TI process begins with a call for proposals that outlines the terms and conditions of the intended purchase, identifies a set of benchmarks and prescribes the required format for vendor responses. The call requests balanced HPC system proposals with rough order of magnitude pricing. The vendors are notified of the intent to solicit proposals through public announcements and are

Table 5. Major Shared Resource Centers High Performance Computing Capability (Fiscal Year 2002)

Major Shared Resource Center	Processors	Total Memory (gigabytes)	Total Capability (gigaflops)
Aeronautical Systems Center (ASC), Wright-Patterson AFB, OH			
SGI Origin 2000/195	128	128	51
SGI Origin 2000/195	384	192	154
IBM SP/375	528	528	792
Compaq ES-40/833	64	64	107
Compaq SMP EV-67, ES-320	128	128	205
Compaq ES-45	836	836	1,672
Army Research Laboratory (ARL), Aberdeen Proving Ground, MD			
SGI Origin 2000/300	256	256	153
SGI Origin 2000/250	128	112	64
Sun E10000	128	128	102
Sun E10000	128	128	102
IBM SMP/375 16-way	512	512	768
SGI SN1/400	768	512	615
IBM NH2	768	576	1,152
Engineer Research and Development Center (ERDC), Vicksburg, MS			
Cray T3E-1200	768	200	921
SGI Origin 3000	512	512	410
Compaq-ES-40	256	256	426
Compaq ES-45	512	512	1,024
Naval Oceanographic Office (NAVO), Stennis Space Center, MS			
IBM SMP/375	1,336	1,288	1,932
Cray T3E-900	1,088	400	967
Cray SV1EX-4	64	256	128
Cray SV1	32	32	38
Sun E10000 64-way SMP	64	64	51

Note: Current as of February 2002.

invited to attend an informational meeting to ensure that all interested parties understand the ground-rules. Proposals received are evaluated based on benchmark performance, relative cost-performance, usability, and confidence criteria. The Collective Acquisition Team (CAT), comprised of site representatives, HPCMO staff and a user representative, construct purchasing options that provide high value to the program. A second request for quotes is then issued to solicit best and final pricing for specific systems that make up the highest value options. Final recommendations are presented to the Source Selection Authority (SSA) for action. Factors such as local user requirements, site expertise, power and space limitations, and the number of different architectures that exist at a site contribute to the recommended allocation of equipment among the MSRCs. To maintain an emphasis on buying larger capability systems, procurement resources are targeted for two major and two minor purchases each year at the four MSRCs. This allows time for sites to integrate new HPC hardware between major purchases and build infrastructure or fine-tune HPC systems during their "off-years".



Bottom dissolved oxygen (mg/l) is plotted in plain view from a Chesapeake Bay simulation, where the red areas indicate depleted dissolved oxygen that typically occurs in the summer and early fall.

Impact to DoD: *DoD scientists, using high performance computers, are able to examine environmental impacts without endangering aquatic environments*

The trend for corporate-wide initiatives to address common issues gathered momentum during fiscal year 2001. The process of building the centers' wide area computing environment continued, including the beginning of a grid computing effort. The program established test beds that allow a central queue to receive computational work (jobs). The queue determines which computational environment in the available pool (which could be geographically separated by 1000's of miles) will run the job fastest. Cooperation activities with other Federal Agencies will continue to develop this technology. The program will continue to provide user training and interaction with other government agencies, industry, and academic centers so that defense scientists and engineers can take advantage of the latest high performance computing expertise, capabilities, standards, and infrastructure.

Major Shared Resource Centers, Fiscal Years 2002 and 2003

The program will continue the success of the TI-01 process by implementing Technology Insertion 2002 (TI-02). TI-02 is a continuation of carefully planned and successfully executed enhancements to the HPC infrastructure. The specific goals of TI-02 are to improve the program's ability to satisfy documented user requirements; to base acquisitions on program-wide criteria; to refine the benchmark suite to support this and future acquisitions; and to ensure the government obtains the best value.

The centers will gain additional high performance computing systems, mass storage, and scientific visualization capabilities. The multi-year process of building the MSRC's wide area computing environment will continue as well with a continuing emphasis on grid computing.

Distributed Centers

Distributed centers (DCs) are selected annually for a one-time investment in high performance computing equipment. Typically, the equipment is no longer in the high performance computing class after two to three years. If a DC is not selected for an upgrade in computational capability during this period, the center may be transitioned from the HPCMP to the parent Service or Agency under the HPCMP program's transition policy.

The DUSD(S&T) made awards to the Naval Research Laboratory, the Army High Performance Computing Research Center, and the Arctic Region Supercomputing Center DCs to purchase high performance computer equipment totaling $35.15 million during fiscal year 2001.

Table 6 shows the fiscal year 2002 high performance computing systems at the DCs. The total peak gigaflop computational capability at the distributed centers was about 4,500 gigaflops at the end of fiscal year 2001. Table 7 lists the program's fiscal year 2001 DCs, which are unchanged from fiscal year 2000.

Distributed Centers, Fiscal Year 2002

Investment decisions at the DCs are determined through an annual competitive process. Selected DCs (Arctic Region Supercomputing Center (ARSC), Fairbanks, AK and Maui High Performance Computing Center (MHPCC),Kihei, HI) received RDT&E funding as part of the HPCMP annual budget. Five DCs were competitively selected to receive HPC capital investments funds from the HPCMP in fiscal year 2002: Air Force Research Laboratory, Information Directorate, (AFRL/IF), Rome, NY; Arnold Engineering Development Center (AEDC), Arnold AFB, TN; Naval Air Warfare Center, Aircraft Division (NAWCAD), Patuxent River, MD; Naval Research Laboratory (NRL), Washington, DC; and the U.S. Army Space and Missile Defense Command (SMDC), Huntsville, AL. In addition, a significant investment will be made at the Army High Performance Computing Research Center (AHPCRC). The investments will support mission-specific, technical challenges at each center. During fiscal year 2002, the HPCMO will continue to work with the Services, Agencies, HPCAP, and other stakeholders to refine the policies and processes used to determine the suitable mix of distributed centers and the appropiate level of oversight they require. The HPCMO's focus will be to ensure adequate resources are available to support Service/ Agency priority projects, and to alleviate administrative burdens.

Distributed Centers, Fiscal Year 2003

During fiscal year 2003, the HPCMO will implement the changes developed in fiscal year 2002. The program will continue to review the

Table 6. Distributed Centers High Performance Computing Capability (Fiscal Year 2002)

Distributed Centers	Processors	Total Memory (gigabytes)	Total Capability (gigaflops)
Air Armament Center (AAC), Eglin AFB, FL			
SGI Origin 2000	20	20	10
SGI Onyx Reality	32	8	13
SGI Onyx2	36	36	22
Air Force Flight Test Center (AFFTC), Edwards AFB, CA			
SGI Onyx2	24	9	16
SGI Onyx2	24	9	16
SGI Origin 3800	64	48	54
Air Force Research Laboratory Information Directorate (AFRL/IF), Rome, NY			
Sky Excalibur	384	26	640
Air Force Research Laboratory Sensors Directorate (AFRL/SN), Wright-Patterson AFB, OH			
Mercury MP-510	64	16	205
Mercury MP-510	96	24	307
Arctic Region Supercomputing Center (ARSC), Fairbanks, AK			
Cray SV1EX	32	8	64
Cray T3E	272	68	230
IBM P3/SMP	200	92	276
Army High Performance Computing Research Center (AHPCRC), Minneapolis, MN			
Cray T3E-1200	1,088	544	1,300
Arnold Engineering Development Center (AEDC), Arnold AFB, TN			
HP V2500	32	32	70
HP V2500	64	64	140
HP V2500	32	32	70
SGI Origin 2000	64	32	38

Note: Current as of February 2002.

Table 6—*Continued*. Distributed Centers High Performance Computing Capability (Fiscal Year 2002)

Distributed Centers	Processors	Total Memory (gigabytes)	Total Capability (gigaflops)
Joint National Integration Center(JNIC), Schriever AFB, Colorado Springs, CO			
SGI Origin 2400	64	32	32
SGI Origin 2000	32	16	16
SGI Origin 2000	32	16	16
SGI Origin 2000	128	128	77
Maui High Performance Computing Center (MHPCC), Kihei, HI			
IBM P3/SMP (16-way)	716	358	1,074
IBM P2SC	160	80	102
IBM SP3	320	160	480
IBM P2SC	32	8	15
IBM P2SC	32	20	21
IBM Netfinity Cluster (933)	520	260	478
IBM Netfinity Cluster (933)	8	4	7
IBM Netfinity Cluster (933)	56	28	52
IBM P2SC	19	4	9
IBM P2/SMP (8-way)	64	8	14
IBM P3/SMP (16-way)	64	32	96
IBM P3/SMP (8-way)	32	16	48
Naval Air Warfare Center Aircraft Division (NAWCAD), Patuxent River, MD			
SGI Onyx2	28	16	12
SGI Onyx2	28	8	11
SGI Onyx3	32	12	23
SGI Onyx3	32	12	23
SGI Origin 2000 (4 systems)	30	4	24
Naval Air Warfare Center Weapons Division (NAWCWD), China Lake, CA			
SGI Onyx2	32	12	20
SGI Onyx2	32	12	20
Naval Research Laboratory (NRL), Washington, DC			
SGI Origin 3800	128	128	107
Sun Ultra	64	15	20

Note: Current as of February 2002.

Table 6—*Continued*. Distributed Centers High Performance Computing Capability (Fiscal Year 2002)

Distributed Centers	Processors	Total Memory (gigabytes)	Total Capability (gigaflops)
Redstone Technical Test Center (RTTC), Redstone Arsenal, AL			
SGI Origin 2000	32	13	33
SGI Origin 2000	32	13	33
SGI Origin 3800	32	16	29
SGI Origin 3800	32	16	29
SGI Onyx2	16	8	16
SGI Oniyx2	16	6	16
SGI Origin 2400	16	8	12
Space and Missile Defense Command (SMDC), Huntsville, AL			
SGI Origin 2000 (Sim Cen)	128	32	52
SGI Origin 2000 (ARC)	96	30	55
SGI Origin 2000 (ARC)	96	48	59
SGI Origin 2000 (ARC)	16	8	12
SGI Origin 2000 (ARC)	48	12	29
SGI Origin 2000 (ARC)	48	12	20
SGI Origin 3800	64	64	59
Cray SV1E	16	32	32
Space and Naval Warfare Systems Center (SSCSD), San Diego, CA			
HP V2500	16	24	28
HP V2500	16	24	28
HP Superdome	48	48	105
HP Superdome	48	48	105
SGI Onyx2	24	12	9
Tank-Automotive Research, Development and Engineering Center (TARDEC), Warren, MI			
SGI Power Challenge	28	6	11
SGI Onyx2	32	31	16
White Sands Missile Range (WSMR), NM			
SGI Origin 2000	64	24	32
SGI Origin 2000	64	24	32
SGI Origin 2000	64	24	32

Note: Current as of February 2002.

Table 7. Distributed Centers

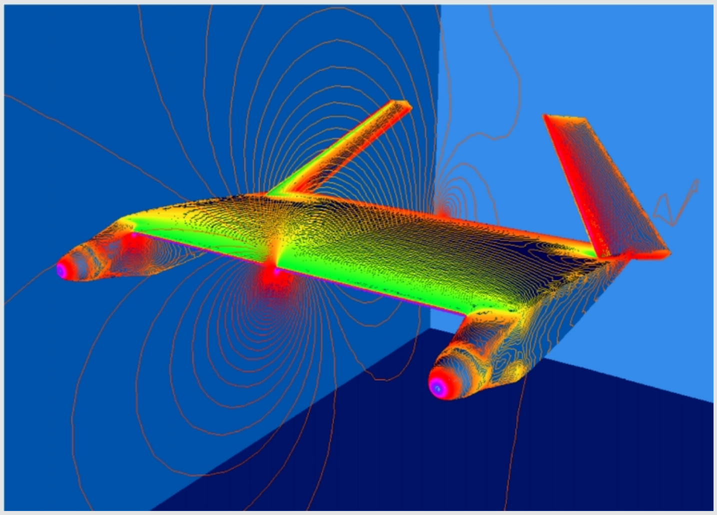
Center	Location	Most Recent Upgrade
Real-Time Focused Centers		
Air Armament Center (AAC)	Eglin AFB, FL	1999
Air Force Flight Test Center (AFFTC)	Edwards AFB, CA	2000
Air Force Research Laboratory, Information Directorate (AFRL/IF)	Rome, NY	2002
Air Force Research Laboratory, Sensors Directorate (AFRL/SN)	Wright-Patterson AFB, OH	2000
Arnold Engineering Development Center (AEDC)	Arnold AFB, TN	2002
Joint National Integration Center (JNIC)	Schriever AFB, CO	1999
Naval Air Warfare Center Aircraft Division (NAWCAD)	Patuxent River, MD	2002
Naval Air Warfare Center Weapons Division (NAWCWD)	China Lake, CA	1999
Redstone Technical Test Center (RTTC)	Huntsville, AL	2000
Space and Naval Warfare Systems Center (SSCSD)	San Diego, CA	1999
Tank Automotive Research, Development and Engineering Center (TARDEC)	Warren, MI	1999
White Sands Missile Range (WSMR)	White Sands Missile Range, NM	1998
Non-Real-Time Focused Centers		
Arctic Region Supercomputing Center (ARSC)	Fairbanks, AK	2002
Army High Performance Computing Research Center (AHPCRC)	Minneapolis, MN	2002
Maui High Performance Computing Center (MHPCC)	Kihei, HI	2002
Naval Research Laboratory (NRL-DC)	Washington, DC	2002
Space and Missile Defense Command (SMDC)	Huntsville, AL	2002

progress and achievements of previously selected DCs, and (providing the fiscal year 2003 budget is sustained) continue to make investments in high performance computing equipment at DCs.

NETWORKING

DEFENSE RESEARCH AND ENGINEERING NETWORK

The Defense Research and Engineering Network (DREN) is a robust, high-speed network that provides connectivity between the HPCMP's geographically dispersed user sites and shared resource centers. DREN provides gateways to many existing military and civilian networks, allowing



Surface pressure distribution on a micro air vehicle (MAV)

Impact to DoD: *DoD engineers are using high performance computers to better understand the thrust and lift generation mechanisms in flapping foil propulsion which impacts submersibles, maneuvering, and the aerodynamics of MAVs.*

access to the program's resource centers from contractor and university facilities.

The wide area networking portion of the HPC community is in the process of being accredited at the Sensitive but Unclassified system level. Each enclave, both classified and unclassified, is already accredited at the edges.

In March 2000, the DREN underwent formal program review; evaluation comments characterized the initiative as outstanding. In August 2000, the Assistant Secretary of Defense (Command, Control, Communications and Intelligence) recognized DREN as the DoD's research and engineering network.

A Request for Proposal was released in January 2001 for a 10-year follow-on contract. The new DREN contract is expected to be awarded in the second quarter of fiscal year 2002 and will be a best value award under full and open competition. The contract will have a base period of three years and seven one-year options. It is anticipated that the new vendor will provide a very high capacity, state-of-the-art backbone with new high speed interfaces, more stringent performance parameters, and new services such as IPv6, increased security, and maximum flexibility for technology insertions.

DREN, Fiscal Year 2002

During fiscal year 2002, the major emphasis will be the transition to the new DREN contract. Network connectivity will be sustained and bandwidth increased. DREN will continue to support test bed environments and facilitate the distributed computing environments across the program's MSRCs and selected DCs. The long term objective of this effort is to optimize sharing of valuable DoD HPCMP resources across centers by supporting dynamic, real-time, ubiquitous computing environments; providing better protection during times of disaster or extended outages; and by eliminating single points of failure.

DREN, Fiscal Year 2003

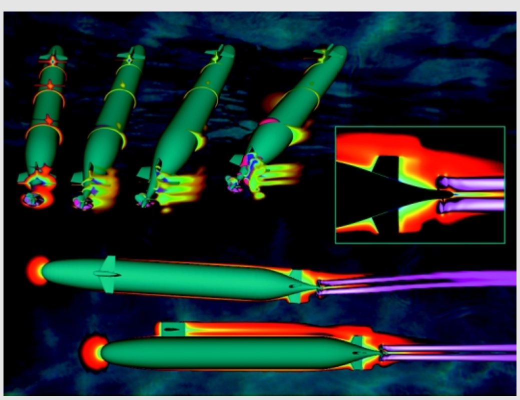
During fiscal year 2003, the HPCMP will continue to increase bandwidth and to support test bed environments and facilitate the distributed computing environments across the program's MSRCs and selected DCs. The very high-bandwidth DREN will be the key to success, since individual centers will need immediate, bandwidth-intensive connectivity to move increasingly larger data sets and resource sharing at low latencies.

Security

Security at HPCMP sites and on the DREN continues to evolve and improve. During 1999, the HPCMP implemented the *Uniform Use-Access Policy for Unclassified DoD HPCMP Resources* to ensure that security requirements for obtaining accounts at all HPCMP shared resource centers are adequate to protect HPC resources. In September 2001, the *Uniform Use-Access Policy for Unclassified DoD HPCMP Resources* was revised to address Foreign National (FN) use of computer systems. The revision states that, while interim access is permitted for most new users based on initiation of the appropriate trustworthiness application, a FN is not allowed interim access. The program also instituted independent NSA assessments at MSRCs and selected DCs. These assessments provided an independent review and verification of the sites' security postures. Centralized network intrusion detection systems (NIDS) coverage has been expanded to all HPC centers and at access points where the DREN meets the Internet and other networks. The HPCMP Computer Emergency Response Team (CERT) is in place to support all HPCMP users. The HPCMP continued a joint project with the Department of Energy (DOE) to improve the DOE-owned Joint Intrusion Detection (JID) software used on the HPCMP NIDS. HPCMP researchers at the Army Research Laboratory modified the JID software so that it can monitor high-speed Asynchronous Transfer Mode (ATM) network traffic. The project improvement increases the number of locations that perform intrusion detection and allows the program to monitor all DREN traffic. The project is complete and the ATM JIDS are now available in OC-3 and OC-12 versions. The program has also increased the level of security filtering done across the DREN. In concert with the Services and Defense Information Systems Agency (DISA), access control lists (ACLs) on devices at network access points have been expanded to provide increased protection from known sources of attack. HPCMP ACLs are coordinated with the Services and DISA lists to ensure coverage that meets all DoD criteria.

Software Applications Support

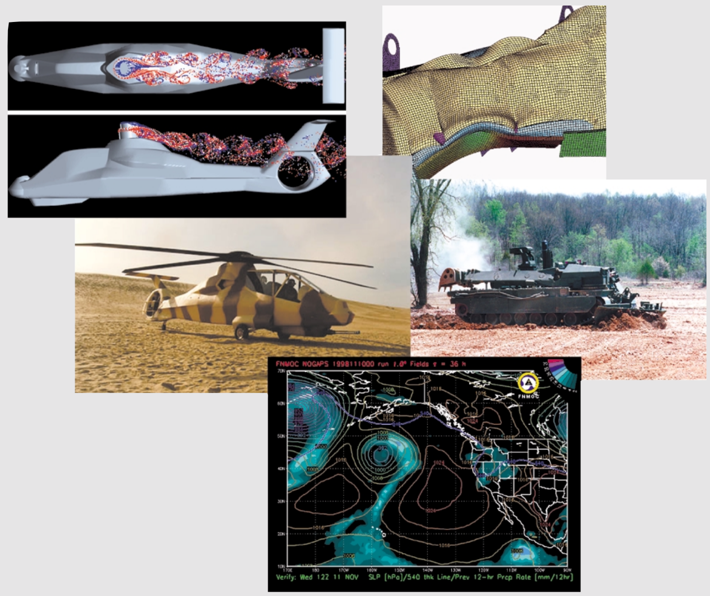
Software Applications Support contains three areas: the Common High Performance Computing Software Support Initiative (CHSSI), which has been producing efficient



Turning maneuver induced by a 10 degree rudder deflection (selected views)

Impact to DoD: *Naval engineers are using high performance computers to reduce design costs and support improvements in the design and operational safety of submarines.*

applications software codes for the last several years, Programming Environment and Training (PET), which is realigned from the HPC Shared Resource Centers, and Software Protection. PET activities will continue to be associated with both Shared Resource Centers' and Software Applications Support activities.



Software Applications Support (Starting Counter Clockwise): *Simulation of the flow unsteadiness on the tail-buffet of the Comanche Helicopter. Picture of a Comanche Helicopter. Scalable Global Weather Forecast System: CWO project to develop and validate scalable and portable atmospheric models using the Navy Global Atmospheric Prediction System (NOGAPS). Mine clearing apparatus. Grid design of a mine clearing blade subjected to land mine explosion.*

Common High Performance Computing Software Support Initiative

The program office promulgated a call for proposals for CHSSI projects to DoD laboratories and test centers in fiscal year 2000. Numerous proposals were received and evaluated. Seventeen new CHSSI projects were selected for initiation at the start of fiscal year 2001. CHSSI completed the fiscal year 2001 selection process and started three new portfolios: Materials by Design, Sensor/ Scene Processing and Generation, and System-of-Systems Simulation.

CHSSI continued to develop, test, and release software in fiscal year 2001 to take advantage of advances in high-speed computing and communications technology, especially in distributed computing, wide-area computing environments, massively parallel high performance computing architectures, and remote desktop collaboration.

CHSSI, Fiscal Year 2002

The initiative provides scientists and engineers, especially those in the test and evaluation community, an easily understandable view of what the program has done, what the program is doing, and what the program hopes to accomplish. A uniform and user-friendly reporting system is being established for the CTA Leaders. This will provide an accessible status of projects and portfolios, reduce the need for special data calls, and provide HPCMP management with relevant data. An extranet page was established to keep CTA Leaders up to date on key events and issues, to share progress and concerns, and to provide an accessible repository of policy and procedures documents.

There were six new CHSSI projects selected in fiscal year 2002. The next call for project proposals will be released in May 2002.

CHSSI, Fiscal Year 2003

Software development, testing, and deployment will continue in fiscal year 2002. Some CHSSI projects will reach completion and be deployed to the user community. The HPCMO will solicit and evaluate proposals for new projects. These new projects would allow the DoD to develop and transition additional key DoD applications software to work effectively on new scalable architectures.

Programming Environment and Training

The Programming Environment and Training (PET) vision is to enhance HPCMP user productivity by providing world-class technical support and training through strategic partnerships, and focused enabling-tool development and deployment. The goals of PET are to train and support new and existing DoD HPCMP users with the knowledge and tools to maximize productivity. Other goals are to foster collaboration across functional, Service, Agency, and national HPC communities, and to facilitate the application of HPC and high performance networks on new areas of interest to the DoD.

To accomplish these goals, PET provides an integrated portfolio (short term and long term) of computational science and engineering activities [support, training, targeted development, Minority Serving Institutions (MSIs), graduate and post-doctoral programs, summer internships] conducted by leading HPC institutions and organizations. PET also identifies, evaluates, recommends, adapts, develops, and deploys (in concert with the shared resource centers) enabling software tools and technologies into the shared resource center user environments. PET promotes and deploys collaborative and distributed computing environments to facilitate virtual teaming and computing.

The PET activity was previously a subset of the initial MSRC integration contracts. A full and open competition was determined to be the optimum approach to acquiring these services for a follow-on effort. A Request for Proposal was released in December 2000.

Two contracts were awarded in June 2001 to contractors were High Performance Technologies, Inc. (HPTi) and MOS University Consortium. These contracts, which consist of a three-year base period with five one-year options, have a potential value of $144 million. These two contracts, with representation from over 20 universities and industry partners (Figure 4), were awarded under full and open competition.

The PET activity is now divided into four components to facilitate government oversight. Each component will execute a program that supports the designated functional areas listed in Table 8 on page 41. Functional areas were grouped to encourage synergy among related CTAs, collaboration and interaction between CTA and cross-community functions (e.g., enabling technologies), and to balance the workload across the four components.

PET, Fiscal Year 2002

Programming Environment and Training activities will continue to emphasize distance learning and distributed training, ensuring that defense scientists and engineers can take advantage of expanded high performance computing capabilities as they become available.

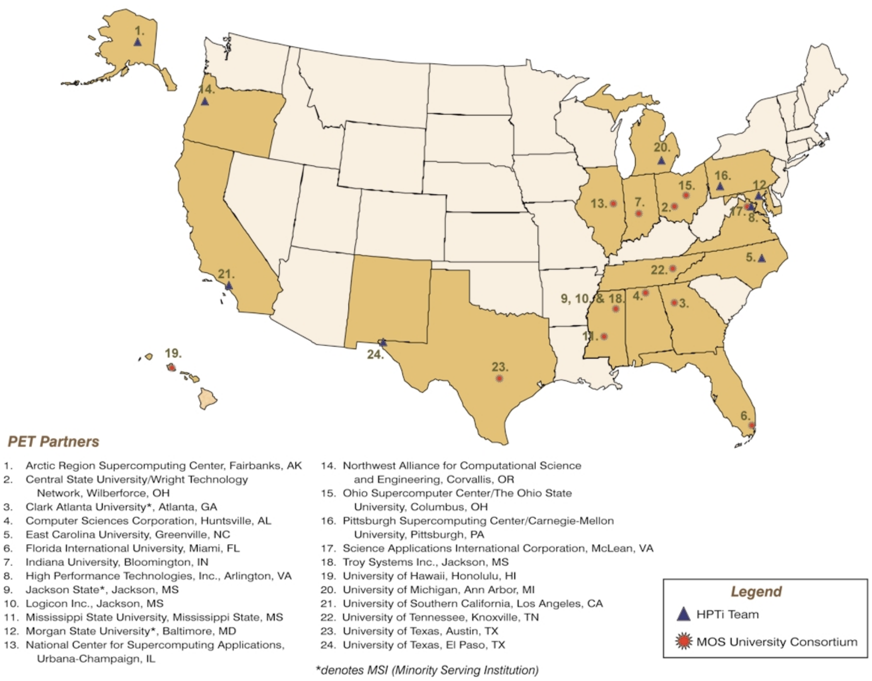


Figure 4. PET Team Members

PET, Fiscal Year 2003

The HPCMP will continue to refine the PET activity based on feedback obtained from users, management, and the contractors. This work will assist the DoD scientists and engineers in exploiting the available HPCMP assets.

User Requirements and Resource Allocations

The HPCMP will improve requirements and user base information gathering from DoD computational projects. Analysis of that data supports program planning and operational decisions. A user-friendlier, web-based version of the requirements questionnaire was developed and will be deployed in fiscal year 2002.

The program will continue its process of allocating valuable HPC resources among the Services and Agencies. This process reserves approximately 25% of total HPCMP resources for DoD Challenge Projects. The remaining 75% is allocated by each Service/ Agency among its individual computational projects. In fiscal year 2002, the program will extend its formal Service/Agency allocation process to include not only the MSRCs, but selected DCs as well.

DoD High Performance Computing Challenge Projects

As discussed above, approximately 25% of the program's total computational resources are allocated annually to high-priority Service and Agency projects with very large computational requirements. These mission-critical, computationally intensive DoD Challenge Projects are approved by the Deputy Under Secretary of Defense (Science and Technology). The DoD Challenge Projects Allocation Board—with representatives from each Service, selected Defense Agencies, and the broader HPCMP community—evaluates the proposals.

Forty-one projects were selected for implementation in fiscal year 2002. Many of the projects use multiple hardware platforms and in some cases, multiple shared resource centers. Computationally, these projects were allocated an average of 72 gigaflops-years for fiscal year 2002. Table 9 lists the fiscal year 2002 DoD HPC Challenge Projects. New projects will be selected during fiscal year 2002 for implementation in fiscal year 2003, continuing

Table 8. CTA Component Functional Areas

Component Number	CTAs and Functional Areas
1	Climate/Weather/Ocean Modeling and Simulation Environmental Quality Modeling and Simulation ***Computational Environment***
2	Forces Modeling and Simulation/C4I Integrated Modeling and Test Environments Signal/Image Processing ***Enabling Technologies***
3	Computational Fluid Dynamics Computational Structural Mechanics ***PET Online Knowledge Center*** ***Education, Outreach, and Training Coordination***
4	Computational Chemistry and Materials Science Computational Electromagnetics and Acoustics Computational Electronics and Nanoelectronics ***Collaborative and Distance Learning Technologies***

the annual selection and evaluation process.

The HPCMO will continue to address the special needs of the DoD Challenge Projects. The program office will continue to promote the use of CHSSI software in DoD Challenge Projects. Each year, special DoD Challenge Project sessions will be organized at a set of four national or international meetings, including the HPCMP Users Conference. User satisfaction survey data will be analyzed to determine the differences between DoD Challenge Project user responses and responses from all other users.

Program Oversight and Review

During fiscal year 1998, the HPCMP performed the Initial Operational Test and Evaluation of its systems in compliance with federal statutes and Defense Department regulations. The Joint Interoperability Test Command (JITC) served as the independent test activity and performed the initial operational evaluation of the program. The command witnessed the evaluation of two MSRCs, two DCs, and two CHSSI code development projects as well as site acceptance testing of the DREN.

In January 1999, the JITC issued an Independent Evaluation Report stating the HPC centers and network are operationally effective and operationally suitable. The report stated,

> *The HPCMP is operationally effective and suitable when operated by its intended users in its operational environment.* ***Users generally agreed the HPCMP has revolutionized their ability to conduct scientific and engineering research.*** *[emphasis added] They indicated that problems, while needing attention, are minor to the HPCMP's overall contribution to their research efforts."*

The results of the evaluation represent a significant step for the program in the formal oversight process. The Independent Evaluation Report for CHSSI projects was also favorable. The annual test report to Congress by the Director,

Table 9. DoD High Performance Computing Challenge Projects (Fiscal Year 2002)

Project	Project Leader(s)	Organization
Computational Structural Mechanics		
Evaluation and Retrofit for Blast Protection in Urban Terrain	James Baylot, Tommy Bevins, James O'Daniel, Young Shon, David Littlefield, and Chrisopher Eamon	Engineer Research and Development Center, Vicksburg, MS
Modeling Complex Projectile Target Interactions	Kent Kimsey and Gordon Filbey, Jr.	Army Research Laboratory, Aberdeen Proving Ground, MD
Three-Dimensional Modeling and Simulation of Bomb Effects for Obstacle Clearance	Alexandra Landsberg	Naval Surface Warfare Center, Indian Head Division, Indian Head, MD
Computational Fluid Dynamics		
3-D Computational Fluid Dynamics Modeling of the Chemical Oxygen-Iodine Laser (COIL)	Timothy Madden	Air Force Research Laboratory, Kirtland Air Force Base (AFB), NM
Active Control of Fuel Injectors in Full Gas Turbine Engines	Suresh Menon	Army Research Office, Research Triangle Park, NC
Airdrop System Modeling for the 21st Century Airborne Warrior	Keith Stein, Richard Benney, Tayfun Tezduyar, James Barbour, Hamid Johari, and Sonya Smith	Army Soldier & Biological Chemical Command, Natick, MA
Analysis of Full Aircraft with Massive Separation Using Detached-Eddy Simulation	Kenneth Wurtzler, Robert Tomaro, William Strang, Matthew Grismer, Capt James Forsythe, Kyle Squires, and Phillipe Spalart	Air Force Research Laboratory, Wright-Patterson AFB, OH
Applied CFD in Support of Aircraft-Store Compatibility and Weapons Integration	James Brock, Jr.	Air Force Seek Eagle Office, Eglin AFB, FL
High-Fidelity Analysis of UAVs Using Nonlinear Fluid/Structure Simulations	Reid Melville and Miguel Visbal	Air Force Research Laboratory, Wright-Patterson AFB, OH
High-Resolution Adaptive Mesh Refinement (AMR) Simulation of Confined Explosions	John Bell, Charles Rendleman, William Crutchfield, and Allen Kuhl	Defense Threat Reduction Agency, Alexandria, VA
Hybrid Particle Simulations of High Altitude Nuclear Explosions in 3-D	Stephen Brecht	Defense Threat Reduction Agency, Alexandria, VA
Large-Eddy Simulation of Steep Breaking Waves and Thin Spray Sheets Around a Ship: The Last Frontier in Computational Ship Hydrodynamics	Ki-Han Kim, Dick Yue, and Douglas Dommermuth	Naval Surface Warfare Center, Carderock Division, Bethesda, MD
Large-Eddy Simulation of Tip-Clearance Flow in Stator-Rotor Combinations	Parviz Moin	Office of Naval Research, Arlington, VA
Modeling of Microbubble Drag Reduction Physics	Parney Albright, James Uhlman, and Leonard Iman	Defense Advanced Research Project Agency, Arlington, VA
Multiphase CFD Simulations of Solid Propellant Combustion in Modular Charges and Electrothermal-Chemical (ETC) Guns	Michael Nusca and Paul Conroy	Army Research Laboratory, Aberdeen Proving Ground, MD

Table 9—*Continued*. DoD High Performance Computing Challenge Projects (Fiscal Year 2002)

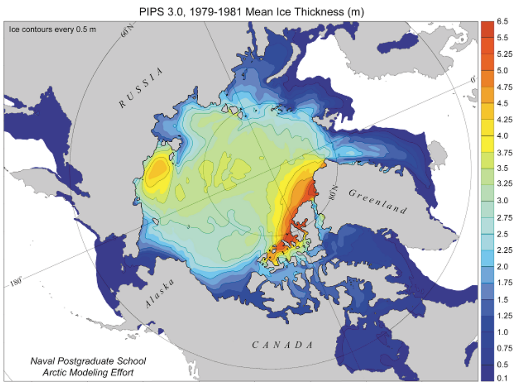
Project	Project Leader(s)	Organization
Computational Fluid Dynamics (continued)		
Numerical Modeling of Wake Turbulence for Naval Applications: Vortex Dynamics and Late-Wake Turbulence in Stratification and Shear	Steve Ardent, Donald Delisi, David Fritts, Maria-Pascale LeLong, James Riley, Robert Robins, and Joe Werne	Office of Naval Research, Arlington, VA
Parallel Simulations of Weapons/Target Interactions Using a Coupled CFD/Computational Structural Dynamics (CSD) Methodology	Joseph Baum	Defense Threat Reduction Agency, Alexandria, VA
Three-Dimensional, Unsteady, Multi-Phase CFD Analysis of Maneuvering High Speed Supercavitating Vehicles	Robert Kunz, Jules Lindau, and Howard Gibeling	Office of Naval Research, Arlington, VA
Time-Accurate Aerodynamics Modeling of Synthetic Jets for Projectile Control	Jubaraj Sahu, Sukumar Chakravarthy, and Sally Viken	Army Research Laboratory, Aberdeen Proving Ground, MD
Time Accurate Computational Simulations of Ship Airwake for DI, Simulation and Design Applications	Susan Polsky	Naval Air Warface Center Aircraft Division, Patuxent River, MD
Unsteady RANS Simulation for Surface Ship Maneuvering and Seakeeping	Ki-Han Kim, Joe Gorski, Fred Stern, Lafayette Taylor, and Mark Hyman	Naval Surface Warfare Center, Carderock Division, Bethesda, MD
Computational Chemistry and Materials Science		
Characterization of DoD Relevant Materials and Interfaces	Emily Carter	Air Force Office of Scientific Research, Bolling AFB, DC
Computational Chemistry Models Leading to Mediation of Gun Tube Erosion	Cary Chabalowski, Margaret Hurley, Dan Sorescu, Roger Ellis, Donald Thompson, Betsy Rice, and Gerald Lushington	Army Research Laboratory, Aberdeen Proving Ground, MD
First Principles Studies of Technologically Important Smart Materials	Andrew Rappe	Office of Naval Research, Arlington, VA
Interactions of Chemical Warfare Agents with Acetlycholinesterase	William White	Edgewood Chemical & Biological Center, Aberdeen Proving Ground, MD
Multiscale Simulations of High Temperature Ceramic Materials	Rajiv Kalia, Aiichiro Nakano, and Priya Vashista	Air Force Office of Scientific Research, Bolling AFB, DC
Multiscale Simulation of Nanotubes and Quantum Structures	Jerzy Bernholc	Office of Naval Research, Arlington, VA
Multi-Scale Simulations of High Energy Density Materials	Jerry Boatz	Air Force Research Laboratory, Edwards AFB, CA
New Materials Design	Jerry Boatz, Ruth Pachter, Mark Gordon, Gregory Voth, and Sharon Hammes-Schiffer	Air Force Office of Scientific Research, Bolling AFB, DC

Table 9—*Continued*. DoD High Performance Computing Challenge Projects (Fiscal Year 2002)

Project	Project Leader(s)	Organization
Computational Electromagnetics and Acoustics		
Airborne Laser Challenge Project II	Wilbur Brown, Jeremy Winick, and Robert Beland	Air Force Research Laboratory, Kirtland AFB, NM
Directed High Power RF Energy: Foundation of Next Generation Air Force Weapons	M. Joseph Arman	Air Force Research Laboratory, Kirtland AFB, NM
Radar Signature Database for Low Observable Engine Duct Design	Kueichien Hill	Air Force Research Laboratory, Wright-Patterson AFB, OH
Seismic Signature Simulations for Tactical Ground Sensor Systems and Underground Facilities	Mark Moran, Stephen Ketcham, George McMechan, Stig Hestholm, Roy Greenfield, Thomas Anderson, James Lacombe, Michael Shatz, Robert Haupt, Richard Lacoss, and Robert Greaves	Cold Regions Research and Engineering Laboratory, Hanover NH
Signature Modeling for Future Combat Systems	Raju Namburu, Theresa Gonda, John Nehrbass, Peter Chung, Maggie Hurley, Steve Bunte, William Coburn, Christopher Kenyon, Calvin Lee, John Escarsega, and William Spurgeon	Army Research Laboratory, Aberdeen Proving Ground, MD
Climate, Weather, and Ocean Modeling and Simulation		
1/32 Degree Global Ocean Modeling and Prediction	Alan Wallcraft, Harley Hurlburt, Robert Rhodes, and Jay Shriver	Naval Research Laboratory, John C. Stennis Space Center, MS
Basin-scale Prediction with the HYbrid Coordinate Ocean Model	Eric Chassignet	Office of Naval Research, Arlington, VA
Coupled Environmental Model Prediction (CEMP)	Wieslaw Maslowski, Julie McClean, Albert Semtner, Robin Tokmakian, Yuxia Zhang, Ruth Preller, and Steve Piacsek	Naval Postgraduate School and Naval Research Laboratory, Monterey, CA
Coupled Mesoscale Modeling of the Atmosphere and Ocean	Richard Hodur	Naval Research Laboratory, Monterey, CA
High Fidelity Simulation of Littoral Environments	George Heburn and Jeffery Holland	Naval Research Laboratory, John C. Stennis Space Center, MS and Engineer Research and Development Center, Vicksburg, MS
Submerged Wakes in Littoral Regions	Patrick Purtell, Roger Britey, Joseph Gorski, and Douglas Dommermuth	Office of Naval Research, Arlington, VA
Signal/Image Processing		
Automatic Target Recognition Performance Evaluation	Timothy Ross	Air Force Research Laboratory, Wright-Patterson AFB, OH

Coupled Environmental Model Prediction (CEMP)

Wieslaw Maslowski and Julie McClean



Impact to DoD: Realistic simulation of the present-day sea ice thickness distribution is crucial to predicting a possibility of partial/ seasonal or full removal of permanent sea ice cover in the Arctic Ocean during the next century.

Evaluation and Retrofit for Blast Protection in Urban Terrain

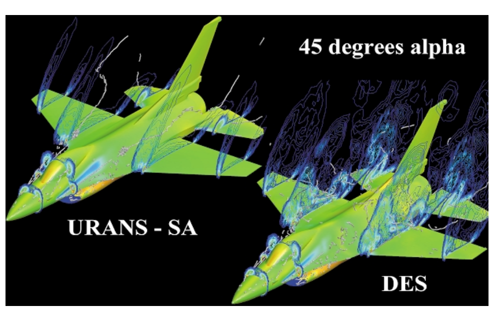
James Baylot

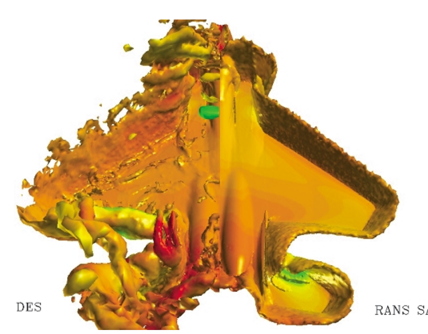
Impact to DoD: Provides an improved methodology for evaluating safety of forces from terrorist attack and for designing retrofits to improve safety.

Analysis of Full Aircraft with Massive Separation Using Detached-Eddy Simulation

Matthew Grismer

Impact to DoD: Allows better prediction of turbulence in massively separated flows around complete aircraft reducing the risk and cost of designing future aircraft.





Operational Test and Evaluation contained no significant findings about the program.

Following the test period, acquisition oversight of the program was formally delegated from the Assistant Secretary of Defense (Command, Control, Communications and Intelligence) to the Deputy Under Secretary of Defense (Science and Technology) (DUSD(S&T)).

In December 1998, the Under Secretary of Defense for Acquisition, Technology, and Logistics formed an Integrated Product Team (IPT) under the leadership of the DUSD(S&T). The IPT, after a year of review, reaffirmed the critical impact high performance computing is having on the DoD. Specifically, they concluded HPC is a critical enabling tool that decreases the time to solution, enables new and innovative approaches, and allows the solution of highly complex, previously unsolvable problems. They further noted that the current HPCMP not only leverages common resources for both the S&T and T&E communities, it also promotes the transition of technology from science and technology (S&T) to test and evaluation (T&E).

In April 1999, the HPCMP established a process to evaluate the effectiveness of distributed center selections. That process is repeated annually (1999, 2000, and 2001).

The program will also continue an aggressive test program to ensure defense scientists and engineers receive high performance computing assets that are operationally effective and suitable for their work efforts. This was also confirmed during fiscal year 2001 as the Director continued his internal performance assessment of the major program components.

Acquisition

In fiscal year 2001, the program office awarded contracts for Technology Insertion 2001 (TI-01), and Programming Environment and Training; the Defense Research and Engineering Network contract will be awarded in fiscal year 2002. The program office is developing an acquisition strategy for follow-on MSRC support contracts and is implementing the TI-02 acquisition. The program office will also be analyzing the possibility of a program-wide software licensing effort.

Impact to DoD: *High performance computing enables more accurate prediction of high frequency, high energy dynamic environments for T&E of Army missiles.*

Program Funding

Funding amounts are based on the High Performance Computing Modernization Program Office's estimate completed in September 2001. The HPCMP is projected to spend \$1.73 billion for fiscal years 2001–2007. Table 10 shows the funding profile by year and major spending category. Within the overall program, the funding level currently supports only a portion of the validated high performance computing requirements (e.g., in fiscal year 2002, the program is providing approximately 40% of the computing capability needed by the user community).

Procurement funding increases provided by Congress in the fiscal year 2000 and 2001 Department of Defense Appropriations Acts, allowed the program to support approximately 40% of the documented requirements in fiscal year 2002. Acquisition Decision Memoranda are issued by the Deputy Under Secretary of Defense (Science and Technology) annually.

A significant fraction of the projected user requirements cannot be adequately addressed by the current funding profile. Therefore, as part of its strategic planning efforts, the HPCMP staff continues to examine options to ensure that the highest priority DoD needs are met in light of these shortfalls. An extensive HPC resource allocation process ensures the program's resources are allocated by the Services and Defense Agencies to the highest priority projects of the Defense Department.

The continued stable funding of the CHSSI and the MSRC sustainment budget lines reflect the importance that the program places on software, integration, and related shared services to its HPC user community. These investments will continue to guarantee that the program's focus remains on enabling users to address warfighter needs, not only by maintaining the support infrastructure, but also by providing effective mechanisms for continued leverage of both national and industrial investments in HPC-based productivity.

TABLE 10. Department of Defense High Performance Computing Modernization Program Funding (Fiscal Years 1997–2007)

Fiscal Year	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007
Procurement (Capital Investments)	122.7	87.1	91.4	95.4	79.0	75.3	49.5	50.4	51.9	53.1	54.2
Research, Development, Test and Evaluation											
Networking (Includes Security)	16.0	21.7	17.0	28.6	34.5	31.2	32.9	30.4	30.9	31.6	32.1
Software Applications Support	21.1	20.9	23.6	20.5	21.9	60.5	54.8	57.4	58.0	60.3	61.5
Major Shared Resource Centers	52.8	72.1	87.6	85.8	88.2	75.0	78.5	78.0	77.5	80.5	80.6
Distributed Centers	28.5	24.3	23.4	26.5	27.1	16.8	22.5	23.4	23.9	24.6	25.1
PROGRAM TOTAL	**241.1**	**226.1**	**243.0**	**256.8**	**250.7**	**258.8**	**238.1**	**239.5**	**242.2**	**250.0**	**253.5**

Acronyms

AAC	Air Armament Center
ACLs	access control lists
AEDC	Arnold Engineering Development Center
AFB	Air Force Base
AFFTC	Air Force Flight Test Center
AFRL/IF	Air Force Research Laboratory Information Directorate
AFRL/SN	Air Force Research Laboratory Sensors Directorate
AHPCRC	Army High Performance Computing Research Center
ARL	Army Research Laboratory
ARSC	Arctic Region Supercomputing Center
ASC	Aeronautical Systems Center
AT&L	Acquisition, Technology and Logistics
ATM	Asynchronous Transfer Mode
CAT	Collective Acquisition Team
CCM	Computational Chemistry and Materials Science
CEA	Computational Electromagnetics and Acoustics
CEMP	Coupled Environment Model Prediction
CEN	Computational Electronics and Nanoelectronics
CERT	Computer Emergency Response Team
CFD	Computational Fluid Dynamics
CHSSI	Common High Performance Computing Software Support Initiative
COTR	Contracting Officer's Technical Representative
COTS	Commercial-off-the-Shelf
CSM	Computational Structural Mechanics
CTA	Computational Technology Area
CWO	Climate/Weather/Ocean Modeling and Simulation
DCs	distributed centers
DDR&E	Director, Defense Research and Engineering
DISA	Defense Information Systems Agency
DoD	Department of Defense
DOE	Depatment of Energy

DREN	Defense Research and Engineering Network
DTOs	Defense Technology Objectives
DUSD(S&T)	Deputy Under Secretary of Defense (Science and Technology)
EBE	Modeling and Simulation of the Electronic Battlefield Environment
EQM	Environmental Quality Modeling and Simulation
ERDC	Engineer Research and Development Center
FMS	Forces Modeling and Simulation/C4I
FN	foreign national
HIE	Hyperspectral Image Exploitation
HPC	high performance computing
HPCMO	High Performance Computing Modernization Office
HPCMP	High Performance Computing Modernization Program
HPTi	High Performance Technology, Inc.
IMT	Integrated Modeling and Test Environments
IPT	Integrated Product Team
JID	joint intrusion detection
JITC	Joint Interoperability Test Command
JNIC	Joint National Integration Center
JWCOs	Joint Warfighting Capability Objectives
JWSTP	Joint Warfighting Science and Technology Plan
MBD	Materials by Design
MHPCC	Maui High Performance Computing Center
Mbps	million bits per second
MSIs	Minority Serving Institutions
MSRCs	major shared resource centers
NAVO	Naval Oceanographic Office
NAWCAD	Naval Air Warfare Center Aircraft Division
NAWCWD	Naval Air Warfare Center Weapons Division
NIDS	network intrusion detection systems
NRL-DC	Naval Research Laboratory-Washington, DC
NSA	National Security Agency
PET	Programming Environment and Training
RTTC	Redstone Technical Test Center
S&T	science and technology
SIP	Signal/Image Processing
SLE	High Fidelity Simulation of Littoral Environments

SMDC	Space and Missile Defense Command
SOS	Systems of Systems Simulations
SPDs	service delivery points
SPG	Sensor/Space Processing and Generation
SSA	Source Selection Authority
SSCSD	Space and Naval Warfare Systems Center, San Diego
T&E	test and evaluation
TARDEC	Tank Automotive Research, Development and Engineering Center
TI	Technology Insertion
TI-01	Technology Insertion 2001
TI-02	Technology Insertion 2002
USD(AT&L)	Under Secretary of Defense (Acquisition, Technolgy, and Logistics)
VPN	virtual private network
WAN	wide area network
WSMR	White Sands Missile Range
WTI	Interdisciplinary Computational Environment for Weapon Target Interations

Department of Defense
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